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24 CASE HISTORIES

HOW PLASTICS SOLVED WAR PROBLEMS

GENERAL ELECTRIC

24 CASE HISTORIES

PRINTED IN U.S.A. 1946

24 CASE HISTORIES

HOW PLASTICS SOLVED WAR PROBLEMS

PLASTICS DIVISIONS
CHEMICAL DEPARTMENT
GENERAL ELECTRIC
NO. 1 PLASTICS AVENUE, PITTSFIELD, MASSACHUSETTS

"Plastics have emerged from the war years with new potentialities. Developments which were speeded tremendously by war pressures have given us added confidence in the great future of this fast-growing industry."

W. H. Milton, Jr.
Manager, Plastics Divisions
General Electric Company

Chemistry Library

FOREWORD

Fifty-two years' experience in plastics

BACK in 1894 General Electric bought the formula and some equipment from a Brooklyn pencil manufacturer—to mold pencil "lead" from a compound of clay and carbon. The product was first used to improve arc lamp carbons. Before the turn of the century, molding techniques were applied to shellac, mica, hard rubber, cumar and other natural resins to provide insulating parts for electrical apparatus.

Plastics and electrical equipment were "futures" that proved to be interdependent. Plastics molding—especially after Dr. Leo H. Baekeland's discovery of synthetic phenolic resin in 1909—was expanded year by year to satisfy General Electric's own needs. Soon it was possible to accommodate more and more outside customers with the G-E plastics service.

The first separate G-E plastics plant was established in 1929, and in 1932 the Plastics Department became a separate organization within General Electric. By 1940 General Electric occupied a unique position in the plastics industry. It was the only unit that was an important factor in every branch—manufacture of plastic materials, molding of finished plastics parts, manufacture and fabrication of laminated plastics.

American industry came to count on G.E. as an unbiased source of technical knowledge and skill in plastics, and as a reliable supplier of plastics parts, particularly precision technical items that required sound engineering and original design.

Exacting specifications were set for plastics parts in war equipment. The availability of plastics became an important factor in war production. The General Electric Plastics Divisions came under production pressure early—and this pressure was never lightened throughout the war years.

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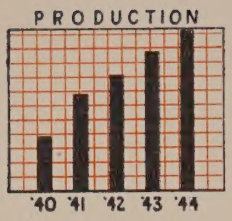

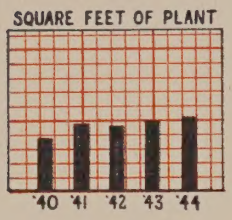

Dollar volume is by no means a true indication of actual production accomplishment during the war, but it is interesting to chart the rise of G-E plastics deliveries. Of course, tonnage of deliveries had an even greater increase.

This threefold increase in dollar volume had to be attained with very nominal increases in employment and square feet of plant, as the charts show. Manpower became a problem, scarcities of plastics materials developed, and the allocation of plant facilities became increasingly difficult.

G-E Quality Control had to be tightened up all along the line—from acceptance of raw materials to final inspection of finished products. Mechanization of plastics processes . . . time-motion studies . . . careful application of wage incentive plans . . . all worked to improve the quality and dependability of technically complex products that had to be mass-produced.

It was estimated that General Electric plastics plants, in 1943, produced over 14,000 different items—97 per cent of the total output being for war use. This booklet presents 24 case histories of wartime plastics problems and how they were solved. Selected for their technical significance, they do not all necessarily represent items which were produced in great volume. But all of these case histories should be interesting and suggestive to those who contemplate a wider application of plastics in their peacetime production.

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MORE THAN 25,000,000 PLASTICS FUSES DELIVERED TO THE ARMY. Mass production level doubled with the same set of molds. Price reduced twice, for a total of over 20 per cent. Every fuse delivered saved a pound of aluminum, and precision-machining.

M-52 MORTAR SHELL FUSE

EARLY IN THE WAR it became apparent that our infantry would need 60- and 81-mm. mortar shells by the millions. Despite the development of new weapons, mortars would continue to be the G.I.'s "portable artillery" . . . the decisive "Sunday punch" . . . according to reports by tacticians from every front.

The business end of every American mortar shell is the M-52 fuse—a three-piece assembly. As originally designed, the body was

an intricate piece of close tolerance metal machining. At that time, bar aluminum stock was soaring high on the list of critical metals. Two-inch screw machines that were needed for shaping, boring and counterboring the body of metal were in short supply. And, even if the machine tools could have been made available, it would have been next to impossible to train machinists in time.

Foreseeing these difficulties, Ordnance brought the problem to G.E. at No. 1 Plastics Avenue. What could plastics techniques offer as a solution?

Pilot production—testing plastics parts

The first step was to modify the design, with due regard to the inherent shrinkage and permissible tolerances of plastics materials. Once the modified design was approved, an intricate hand mold was built for its pilot production. Here the difficulties were six different threads and the interlocking of several of the seven wedges. Hundreds of experimental plastics fuses were made laboriously by hand by skilled craftsmen—enough to give the widest tolerance variation that might conceivably occur in volume production. Assembled, these plastics fuses showed up as well as the original aluminum fuses in actual firing tests at Aberdeen under U. S. Army Ordnance direction.

Putting the M-52 plastics fuse into volume production

General Electric received the go-ahead to put the plastics fuse into volume production.

A whole new transfer-molding technique—one that would have been considered technically impossible until then—was planned. G-E engineers recommended a cotton-flock-filled phenolic of requisite impact strength and laid out strict Quality Control standards.

One hundred and five sets of the intricate mold were built exactly alike—with their semi-automatic accessories.

But perhaps the most difficult phase of this 1,250,000-man-hour program was tooling. It was decided to pioneer, to go to automatic pre-forming of the compound on special rotary machines. And special machines for the semi-automatic disassembly of wedges had to be designed and built.

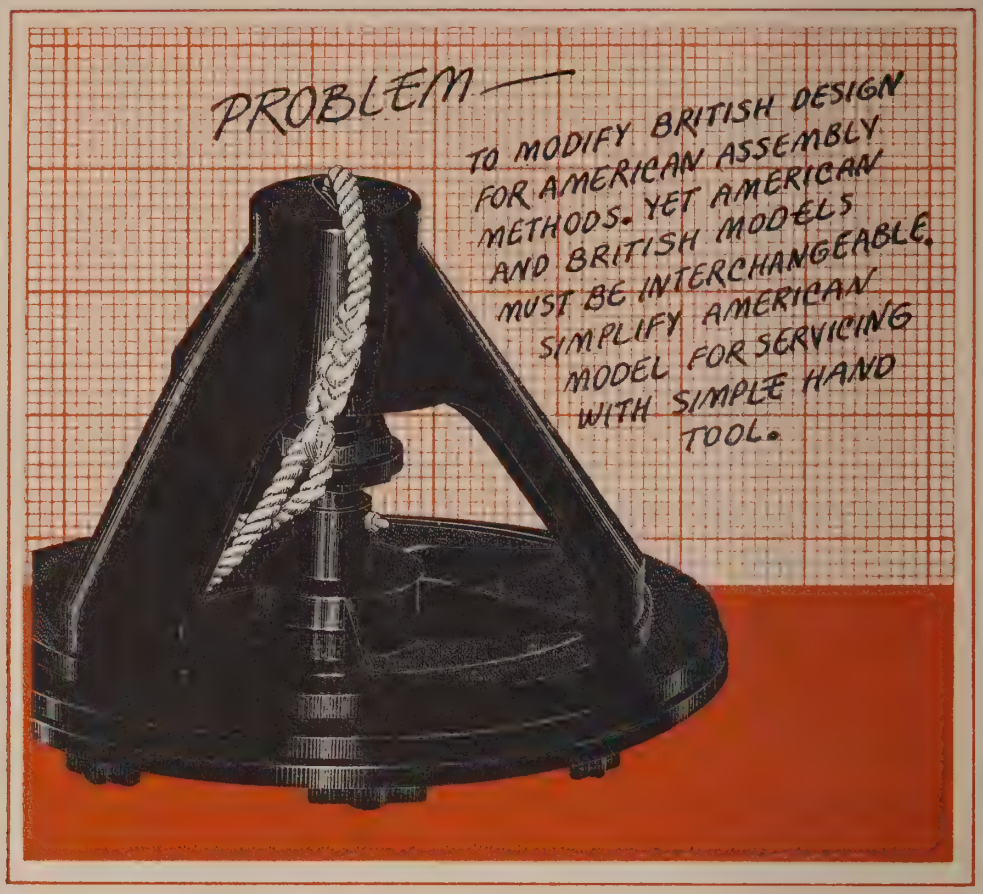
Doubling production from the same molds

From the very beginning, this high degree of mechanization —never before attempted with a transfer-molding process—was more than justified. Still more mortar shell fuses were needed. Special production crews were gaining in efficiency and experience. By improvements in machinery and processes, General Electric went on to double production from the original molds—to over a million plastics fuses a month. And only a few changes were made, such as combining two or more semi-automatic gauging operations into one. Few basic changes had to be made in the course of production aside from changing over to a rag-filled phenolic for the compression-molded booster cup and changing the head over to a heavier die-cast zinc for better "nose-over" characteristics that the Army wanted to attain.

Farsighted production engineering pays off

General Electric made two important price reductions on the M-52 fuse, until the price was reduced by over 20 per cent. And every one of the millions of plastics fuses delivered saved a pound of aluminum and allowed screw machines and skilled operators to be diverted to other vital war work. At the time when General Electric had shipped over 25,000,000 fuses, plastics scrap in G-E plants was only 3.48 per cent of total parts produced.

Here is a case of plastics successfully replacing precision parts machined from metal—and at approximately one-quarter the cost. And such parts could only have been produced in such volume—in time—by plastics techniques.



BRITISH DESIGN WAS SUCCESSFULLY TRANSLATED. And needed barrage balloon safety valves were produced on schedule.

BARRAGE BALLOON RELIEF VALVE

EARLY IN THE WAR, the U. S. Army Corps of Engineers adopted a barrage balloon relief valve which had been designed by British engineers.

The job of producing it in quantity for American-made barrage balloons was turned over to No. 1 Plastics Avenue with important specifications:

(1) British design had to be modified for American line assembly methods;

(2) Yet the proposed American model, in its entirety, had to be interchangeable with its British original;

(3) Unlike the British model, which required a set of special tools for maintenance, the American model had to be engineered for quick disassembly with the simplest of hand tools, a screw driver.

Original British design modified and simplified for American production

Basically the British design was a masterpiece of foolproof simplicity in operation. The barrage balloon relief valve trips open when the bag of the balloon expands past the safety point, closes when the balloon returns to normal. G-E engineers, therefore, had to learn adjustment of spring tension and naval practice in rope splicing. A great deal was learned, too, in translating British blueprints for American production.

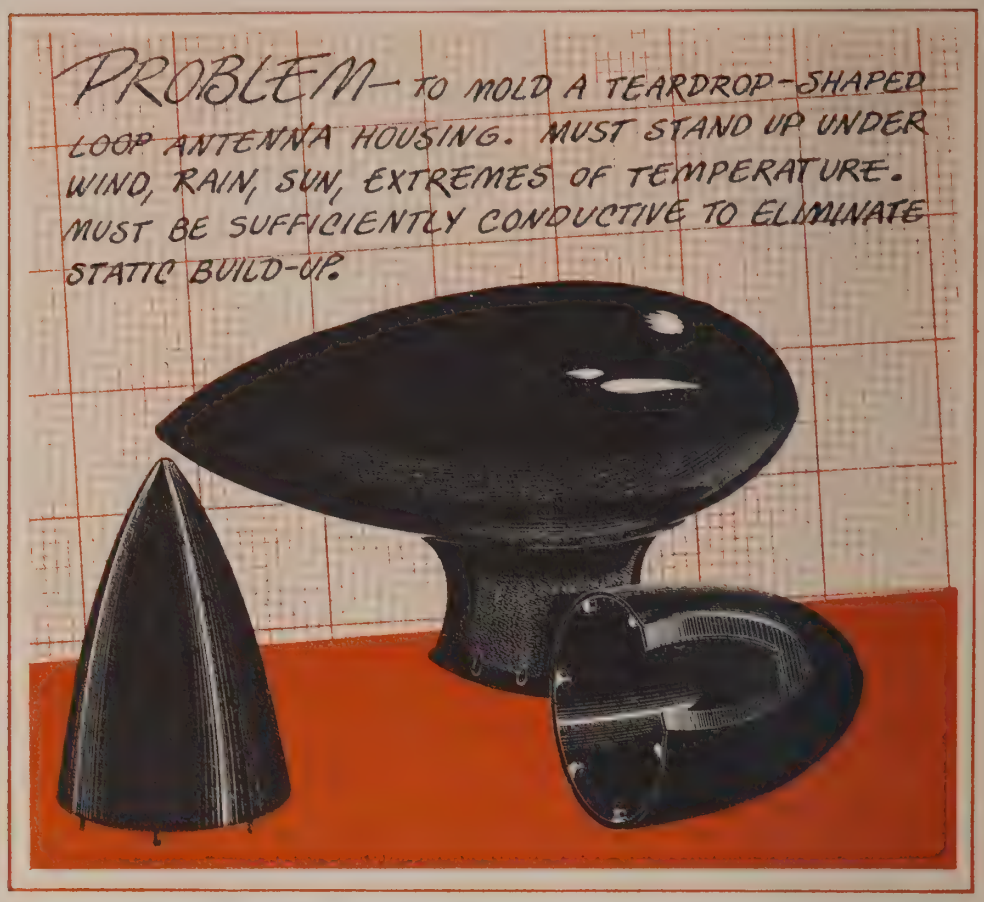
Plastics were specified for the job for lightness of weight and because aluminum was scarce.

Each of the eight parts was simplified in design. It was decided to compression-mold all parts out of G-E Compound 1398—a cotton-flock-filled phenolic. And all outside parts had to have good weathering characteristics. Some difficulty was encountered in fabricating the valve seat to high-quality British gum rubber specifications.

The value of 52 years of experience with precision technical items

Drawing on long experience, G.E. was able to modify the British design and build the molds for the mass production of barrage balloon relief valves in record time. These assemblies were supplied to the Government in G.E.-designed carrying cases, which were made to carry the valve open, to avoid needless wear on the rubber seat. Each carrying case contained easy-to-follow instructions for servicing.

This is a case of prompt and trouble-free translation of a foreign design to American manufacturing methods. As ingeniously simple as this British device was, it could be further simplified for ease of production.



TENS OF THOUSANDS OF PLASTICS LOOP HOUSINGS WERE SUPPLIED FOR BOMBERS. Corrosion and static build-up hazards were eliminated in development.

RADIO LOOP ANTENNA HOUSING

EVER SINCE GENERAL JIMMY DOOLITTLE led the first B-25 raid on Tokyo, American bombers have carried a teardrop-shaped loop antenna housing as standard equipment. Its design is the result of collaboration by the Kearfott Engineering Company and No. 1 Plastics Avenue.

It supersedes a loop antenna housing fabricated from im-

pregnated knit cotton cloth. Slow and costly production of this aircraft component failed to lend itself to the expansion of our air power program. And the finished product did not stand up under the terrific beating of wind, rain, ice, snow, sun, and extremes of temperature.

Splitting teardrop across required molds with exceptionally deep "throats"

The teardrop shape of the new antenna housing—true to aerodynamic design principles for minimum drag—meant that it had to be molded in two sections. To split the teardrop across meant a mold with an unusually deep "throat."

The mold was designed in this way on the basis of past experience, which proved that a lengthwise split of the two sections would be difficult to hold to dimensions for a tight fit. Successful "deep-throat" molds for a cross-section split cut down the chances of the housing getting out of alignment during assembly—facilitated the assembly job itself—and minimized shrinkage and warpage factors.

The most interesting problem had to do with the plastics materials for the job. The two molds, with their deep cavities and long plunger, dictated careful selection of molding compound that would fill out to uniform density. Strict control of the molding cycle and skill of the operator were required to keep a true alignment.

Development

Then, too, tests of early models revealed two undesirable characteristics in the fabric-filled phenolic that had been selected:

(1) Release of ammonia that resulted in corrosion of metal fittings;

(2) Build-up of static electricity that interfered seriously with radio reception.

Corrosion corrected with ammonia-free plastic

The first was corrected by the production of an ammonia-free phenolic by using a one-stage rather than a two-stage resin.

The second was corrected by mixing enough graphite into the molding compound to give just the degree of conductivity to do away with undue static interference.

Airtight cement for bonding nose and tail sections

Then there was the problem of finding an airtight, moisture-proof cement for bonding together the nose and tail sections. A

number of products on the market were tested, and Prestite was found to be satisfactory. Later experiments with silicone rubber gaskets were conducted with good developmental results, but these new gaskets have not yet been put into production.

"Shirttails" had to be free of waterproofing

Appropriately enough, the fabric filler used in the ammonia-free phenolic came from cuttings of fine cotton twill uniform shirts—a by-product supplied by military tailors. These "shirttails" had to be selected, because textile which had been waterproofed for tropical use failed to absorb resin.

Production by the tens of thousands

Once these developmental problems were solved to the satisfaction of Wright Field, it was possible to turn out moldings for new and better loop antenna housings by tens of thousands. The only modifications were minor ones, such as going over to a dull finish to eliminate reflection.

This is an example of applying peacetime experience—difficulty in keeping large longitudinal cross-sections to dimensions for a tight fit—and of pioneering a "deep-throat" mold. The plastics material was formulated to the job at hand.

"DEEP-THROAT" MOLD GIVES VOICE TO OUR BOMBERS. A deep draw and long plungers are required to mold the nose section of the G.E.-made plastics loop antenna housing.

FIGHTING EYES GOT THE "GLASSES" THEY NEEDED. Glass fabric-base radomes were produced by new low-pressure laminating techniques.

RADOMES

HOUSINGS FOR RADAR UNITS require special electrical insulation material with "transparency" to specific wave lengths of radiation. Protection against moisture and good impact strength—particularly against the blast of near-by guns—also are important.

The first housings for radar equipment were made of resin-bonded plywood. But this type of construction proved to be too absorbent—moisture and even high humidity had an adverse effect upon operating efficiency.

The development of spun metal techniques in making large-size molds suggested the possibility of plastics radomes. G.E. worked out a special low-pressure laminating process for the job.

RADOME I

The first G-E-made radomes had a cloth base, using G-E Compound 3203 liquid phenolic resin. This laminate proved to be impervious to moisture. But, when radar switched over to new frequencies, it was not transparent enough to radiation.

RADOME II

In co-operation with the Radiation Laboratory of the Massachusetts Institute of Technology, General Electric plastics engineers developed two single-wall radomes—one with cotton fabric base, the other with glass fabric base. Both had the desired mechanical strength but were deficient in electrical properties.

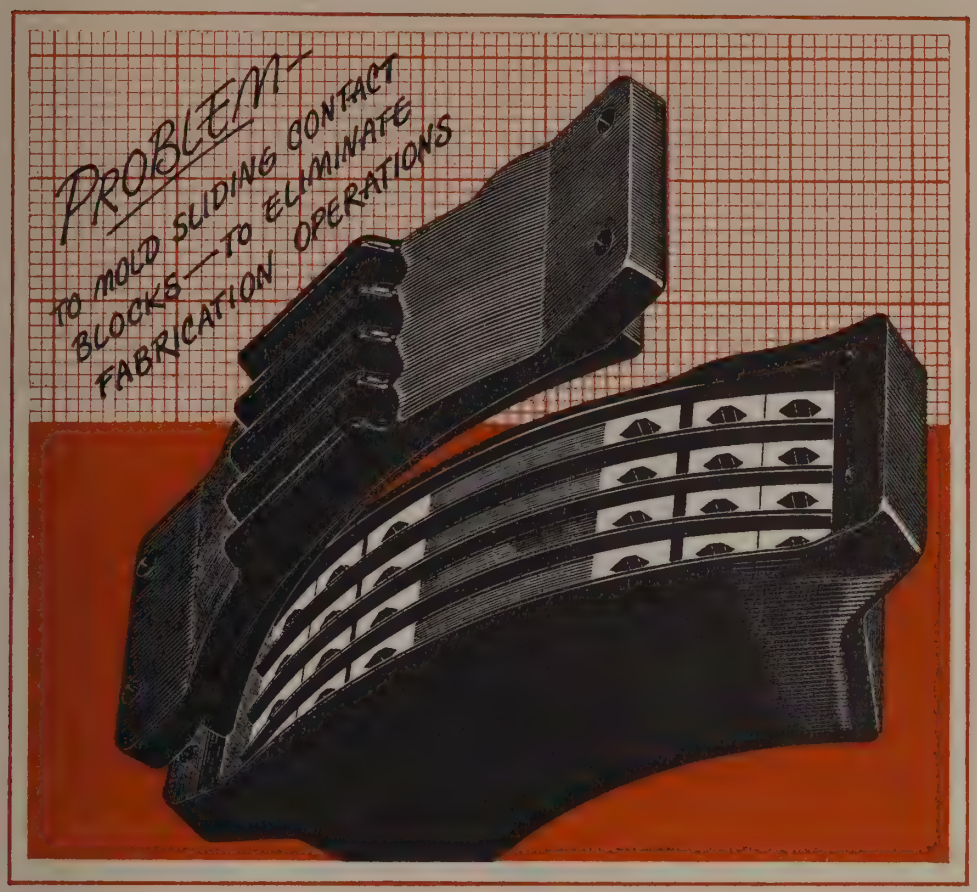
RADOME III

Desired electrical characteristics were attained by an ingenious spacing of double walls of glass fabric base. That entailed sandwich construction, using high-strength laminated faces—precision spaced for improved electrical and mechanical performance. General Electric worked out a technique to do this low-pressure laminating job all at one time in the Engineering Development Laboratory.

Later, the "Eagle" radome, in the shape of the leading edge of the wing of a bomber, was designed and put into production.

This case highlights the potentialities of spun-metal molding and low-pressure laminating techniques in the production of large plastics parts that are lightweight and mechanically strong. It also suggests how plasticians, working with electronics engineers, can overcome an electrical difficulty—transparency to radar waves.

EAGLE RADOME—17 feet long—believed to be the longest low-pressure-laminated part ever manufactured in the plastics industry.



CHANGE-OVER TO MOLDING SAVED TIME AND MONEY. And made parts that stood the gaff of vibration, heat, voltage, and high octane gas.

PITCH CONTROL BLOCK AND COVER

BEHIND THE HUB of the Curtiss-Wright variable pitch propeller is an intricate and vital assembly—the pitch control block and cover.

General Electric was selected as a second source of supply for this component. The G-E contribution was to mold these parts, which had been fabricated in the past, with a distinct gain in durability.

A routine precision job

Dimensionally it was what engineers call a "fussy" job. There were 24 metal inserts that had to be molded in to close tolerances. These are the contact points that transmit electric power to the pitch-changing mechanism . . . that give the pilot automatic control over the angle of propeller "bite."

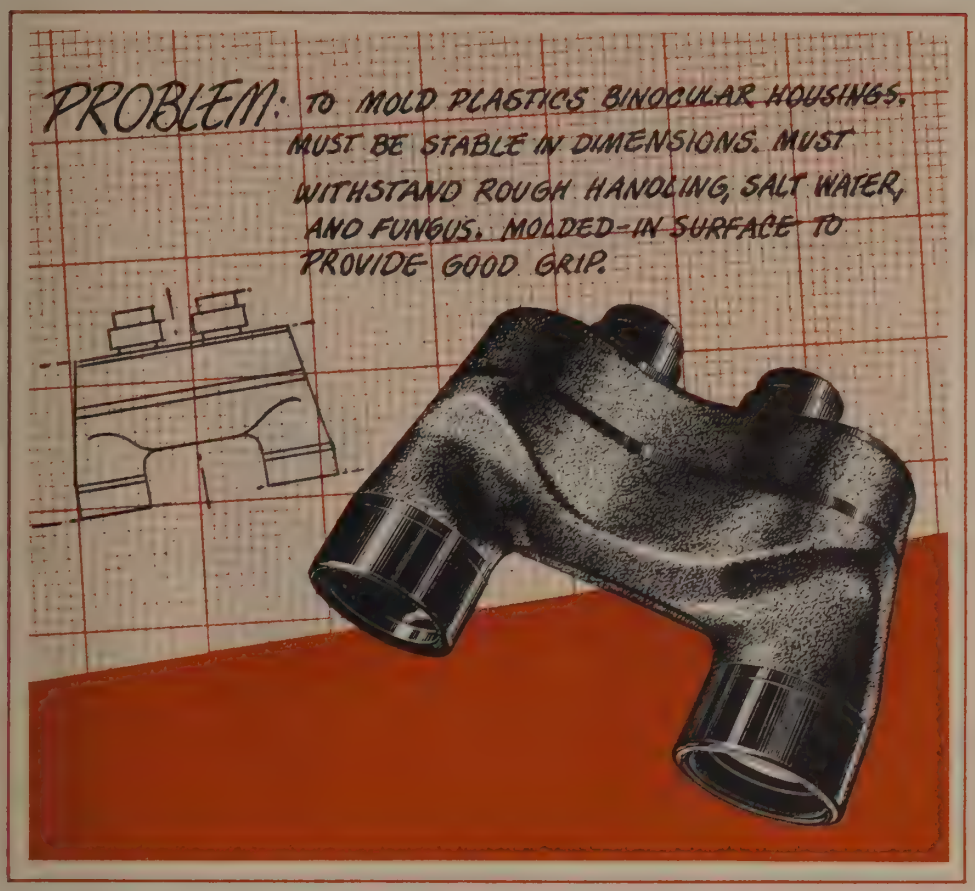
With the exception of the Bulkhead Terminal (see Case History No. 9, page 29), these parts contained more metal by weight than any others molded. The shrinkage factor in the plastics material involved careful planning to obtain firm anchorage of inserts.

Whether installed in a speedy P-40 Warhawk or a payload-carrying C-46 Commando, the precision-molded plastics parts must withstand varying degrees of heat and phases of vibration. They must be impervious to chemical effects of oil and high octane gas. To meet these conditions, G-E engineers selected G-E Compound 1379 phenolic, and specified a high-grade rag as filler.

Intricate molds, with 24 metal-insert-positioning wedges, were made in the G-E toolrooms, and a semi-automatic transfer molding process was set up at Pittsfield for volume production.

All of this was done in record time—with few if any problems arising.

This case is typical of hundreds of war jobs undertaken and carried through at No. 1 Plastics Avenue—by simply applying tried-and-proved plastics techniques. Molding instead of fabricating saved time and money and made better parts.



NEW LONG-RANGE VISION—IN PLASTICS. The new plastics housing makes a fine optical instrument . . . strong . . . light . . . easy to hold . . . impervious to salt water and fungus.

PLASTICS BINOCULAR HOUSING

THE SERVICE BINOCULARS designed by the U. S. Naval Observatory have 6 x 42 universal focus lenses that are specially treated for night vision. These binoculars are fine precision instruments.

As originally designed, these binoculars were encased in aluminum and hard rubber with a leather cover—all scarce materials during the war. Not only to replace these materials but to effect certain improvements, the Navy asked for a plastics replacement.

A plastics housing would make much lighter, easier-to-use

Advantages of a plastics binocular housing

binoculars. Plastics eyepieces would be much safer and more comfortable to use in extremely hot and cold weather. General Electric mixed asbestos filler into the phenolic molding compound—primarily for purposes of dimensional stability and mechanical strength. Asbestos also served to alleviate the fungus problem encountered in the southwest Pacific, because it was inorganic and would not support bacterial life as organic rubber and leather did.

There were a number of interesting problems that were solved in the course of designing a serviceable plastics binocular housing.

Metallurgy works with plastics

A number of die-cast aluminum fittings had to be molded into the two transfer-molded pieces. Metallurgy was called upon to alloy the aluminum as closely as possible to the contraction and expansion characteristics of the plastics material. This did away with the possibility of these metal inserts cracking away from the plastic under arctic or tropical conditions.

Though the walls of the housing were unusually thin for molding in inserts, they proved to have better mechanical strength than the original design.

Collimation in this optical instrument had to be held to a strict tolerance of plus or minus 0.001 inch.

All of these conditions called for an exceptional stability in the molded plastic. This was attained by baking the two transfer-molded parts for a total of 111 hours—in three stages—over a week's time.

Plastics stability attained by protracting the baking process

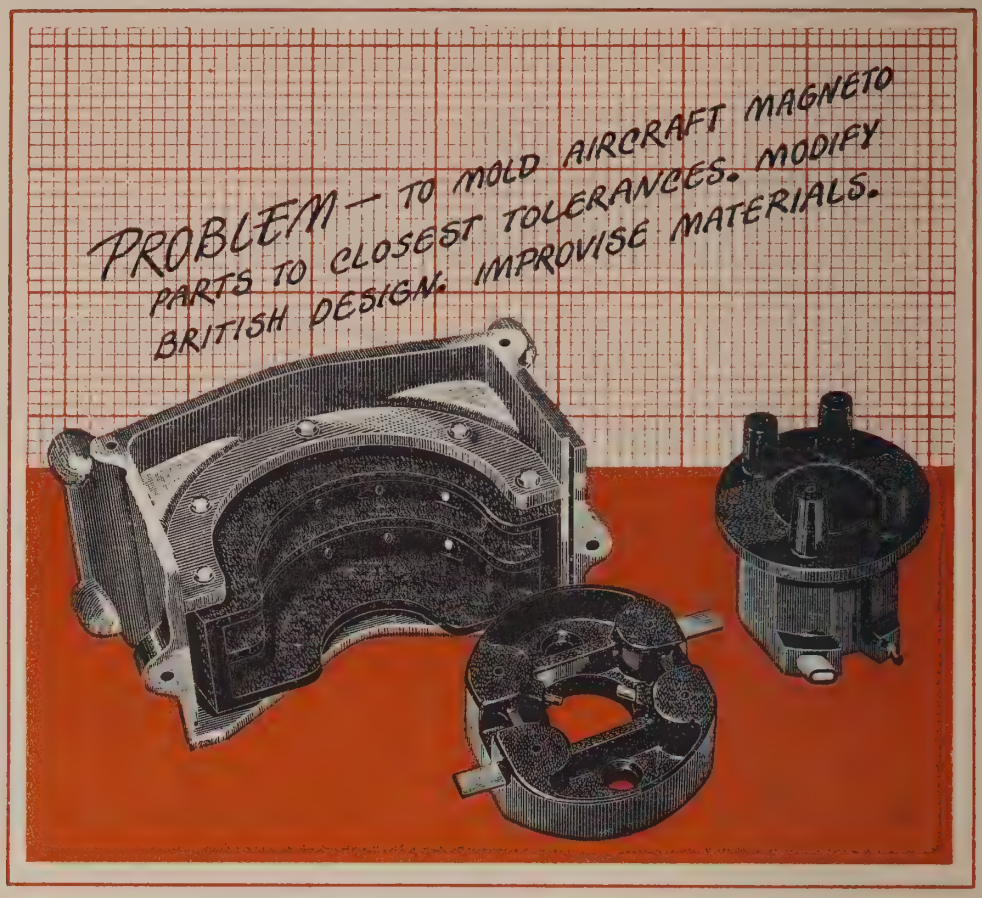
It took artful undercutting of the molds to simulate leather grain for a better grip, as specified by the Navy.

According to tests conducted by the University of Pennsylvania, the new plastics housing proved superior to the original design. Subjected to fungus conditions, it was impossible to see through the old type binoculars after two weeks—but vision was still clear with the plastics binoculars. And the plastics binoculars withstood immersion, without leaking, in 100 feet of water.

Superiority of the plastics binocular housing proved by laboratory tests

In the summer of 1945, the plastics binoculars had not gone beyond pilot production of a few hundred test pieces, but it is regarded as a successful and significant job.

This is a case of plastics and metallurgical techniques working together to produce better plastics-metal parts. By alloying aluminum as nearly as possible to plastics expansion and contractions, metal inserts are protected from cracking away from unusually thin plastics walls. Much was learned about plastics stability and careful control of a protracted baking process.



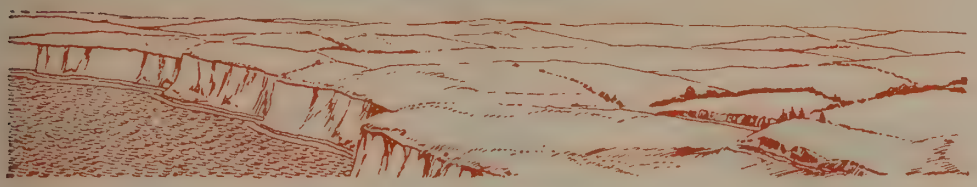
THERE'S HISTORY IN THESE PLASTICS PARTS—For the magneto in the American-made Rolls Royce Merlin aircraft engine.

BRITISH THOMSON-HOUSTON AIRCRAFT MAGNETO

WINSTON CHURCHILL had not yet uttered the words, "Never have so many owed so much to so few," when the Rolls Royce Merlin aircraft engine, which powered Britain's immortal Spitfires, jumped the Atlantic for production in this country by Packard.

A General Electric affiliated company, British Thomson-Houston Co., Ltd., made the magneto for the famous fighter engine

in England—and General Electric undertook to do the same for Packard in the United States. Coventry, the home of British Thomson-Houston, was bombed out. All No. 1 Plastics Avenue had to go on was a set of British drawings and British-made molded insulation parts. And it was difficult to get other important data by trans-Atlantic telephone during the Battle of Britain. Precision requirements were high—parts had to be machined to tolerances as close as plus or minus 0.0005 inch. But the principal problem was to develop materials in the United States that would produce electrically satisfactory and dimensionally stable molded parts—without the guidance of the British designers of the magneto. All things considered, this magneto was General Electric's toughest technical problem.



There were eight different parts, each of which required a different material. General Electric developed one cellulose-filled phenolic aniline compound with special electrical properties—another with both electrical and mechanical properties.

Synthetic rubber problem

But Jap seizure of natural rubber sources presented the most difficult problem. General Electric worked with American Hard Rubber to develop a satisfactory synthetic hard rubber molding material. Vulcanization of synthetic rubber had to be done with hot air rather than conventional techniques used in the rubber industry. And General Electric transfer-molded synthetic hard rubber for the first time in America.

British design stressed all of these materials to their critical limits. It is noteworthy that American- and British-made parts could be kept interchangeable for ease of maintenance round the world.

Even when operational altitudes rose above critical limits, this magneto gave required performance in its application to the Rolls Royce Merlin aircraft engine made in America by Packard for British Hurricanes and Mosquitoes, American Curtiss-Wright P-40 Warhawks and North American P-51 Mustangs, and other warplanes.

This is a case not only of a successful translation of British design to American production—without British engineering supervision—but of an important contribution to synthetic rubber techniques by the American plastics industry.

DOUBLE-FIRING EACH CYLINDER FOR SURE-FIRE PERFORMANCE—from desert heat to sub-zero cold in a matter of minutes.

GENERAL ELECTRIC MAGNETO

THERE ARE TWO General Electric magnetos on each of the Pratt & Whitney 2100-hp engines that power the Republic P-47 Thunderbolt, the Northrop P-61 Black Widow, the Curtiss C-46 Commando, the Douglas A-26 Invader, and the Fairchild C-82 Packet. A double ignition system for these late-model planes is an important safety factor—double-firing of every cylinder.

The General Electric magneto was designed for arc-resistance at high altitudes and to take sudden temperature changes with no

effect on electrical characteristics. The latter was very important for high altitude planes, which may climb from desert heat to sub-zero cold at 35,000 feet in a matter of minutes.

A new melamine molding compound

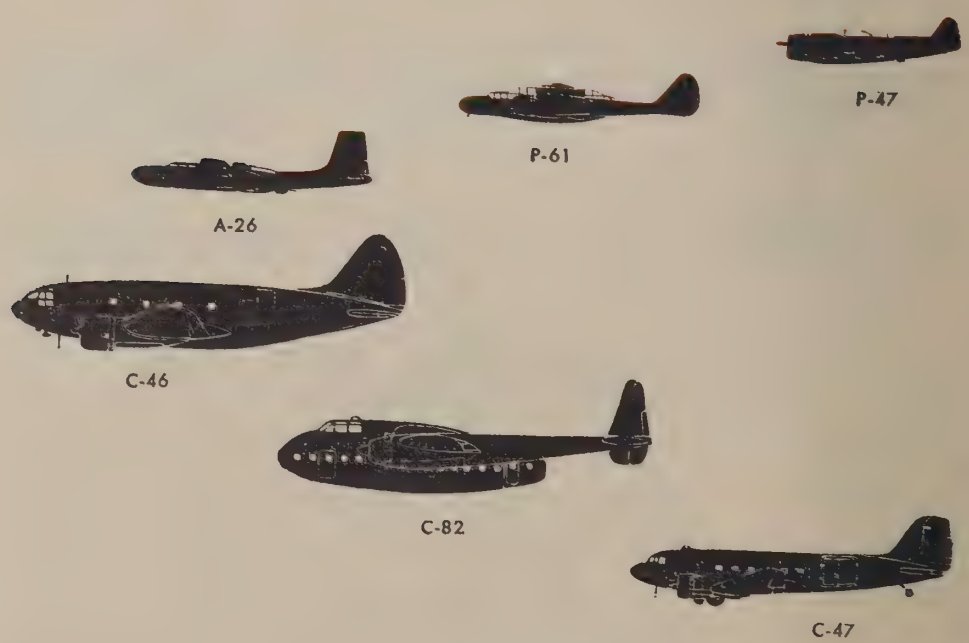
To meet these specifications, General Electric pioneered the use of a new melamine molding compound, for which special molding techniques had to be developed.

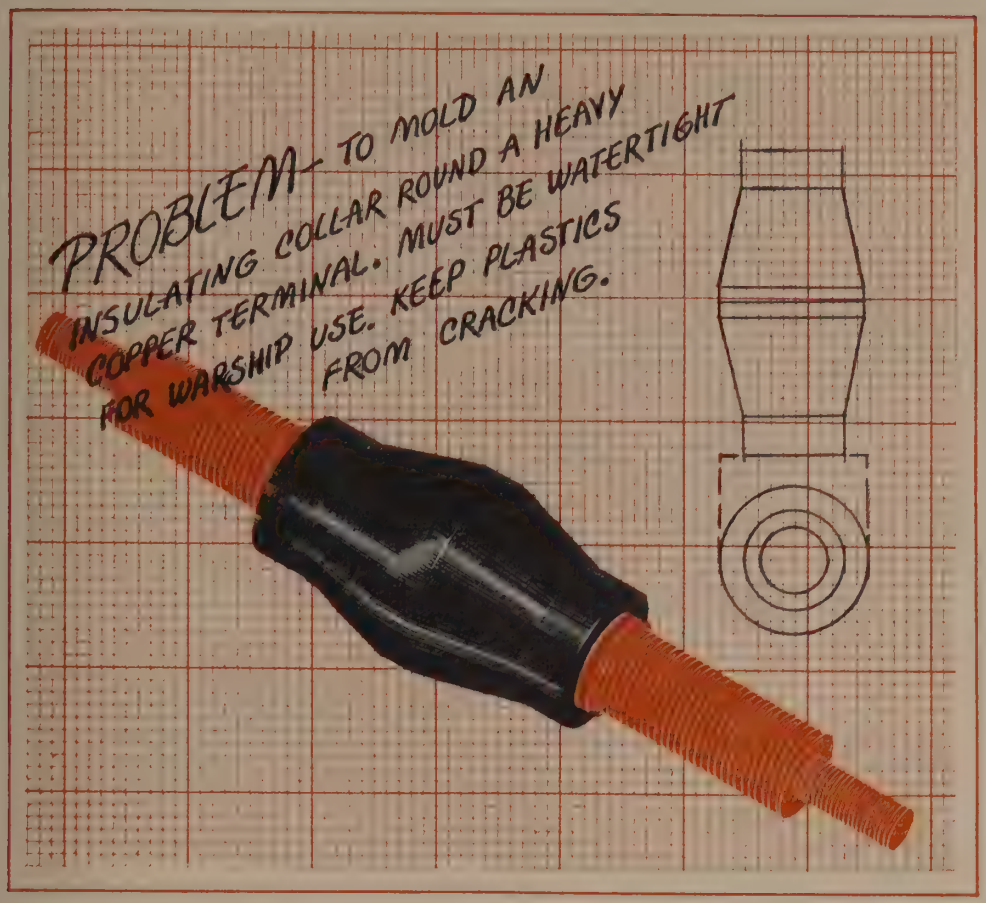
Here industrial electronics played an important role in automatic controls for a series of conditioning preheats and split-second closing of the molds.

Also developed were new control tests that have been applied with success to hundreds of other moldings for aircraft.

The magneto shield withstands Hi-pot at 27,000 volts for 10 minutes and an interesting 7-cycle thermo-shock test: 120 C for 1 hour; room temperature for ½ hour; 40 C for 1 hour; room temperature again for ½ hour—without physical failure.

This is a case of developing a new molding technique for a new material—to fill special war requirements.





SPED THE REPAIR OF A BRITISH WARSHIP. An emergency job finished in a few days.

BULKHEAD TERMINAL FOR THE ROYAL NAVY

ONE OF THE first British warships to be repaired in this country limped into the Brooklyn Navy Yard needing plastics insulating parts for its electrical system. The problem was turned over to General Electric—long a supplier of plastics parts to the U. S. Navy.

Problem of heavy copper insert

What was needed—and as soon as possible—was a terminal to convey electric current through bulkheads for emergency service when permanent circuits were damaged in battle. It was of a design

then unknown in the United States. A heavy piece of machined copper had to be inserted in a watertight, battleship-strong insulating collar of plastics (G-E Compound 1379 brown-rag-filled). The problem was to maintain the pressure between the heavy copper insert and the relatively light plastics insulation. This was accomplished by grooving a series of rubber gaskets into the plastics molding.

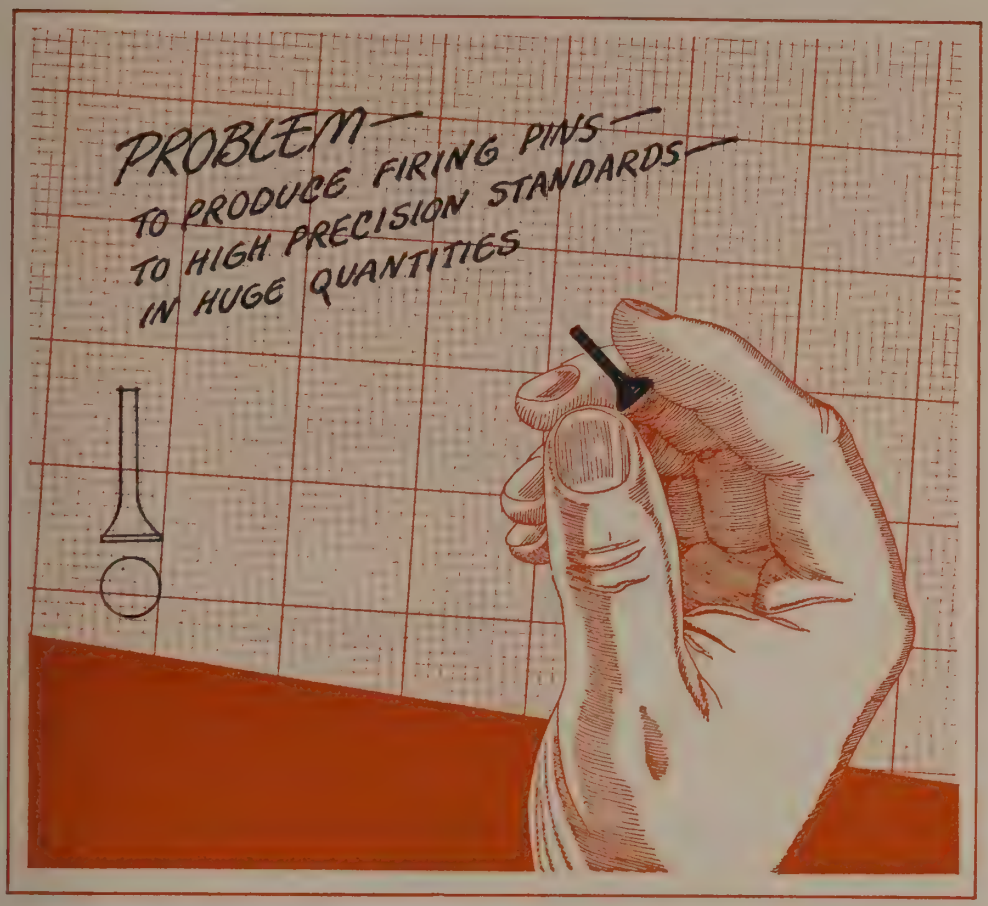
The bucket brigade saves the day

Even then there was trouble with the plastics cracking from the heat built up in the copper during the molding process. This was corrected by the simple expedient of quenching the copper in buckets of water immediately after the piece left the press.

Chief Engineer Warner delivered the first bulkhead terminals —made in a matter of days—personally and in his own car to the Brooklyn Navy Yard. They came up to British specifications in every respect. And repair of the British warship proceeded on schedule.

Later a top priority air express shipment of bulkhead terminals was flown to Seattle to repair another British warship.

This case is typical of many emergency engineering jobs that were tackled by General Electric during the war. The duplication of foreign plastics components—without original engineering specifications and drawings—was always a challenge to American ingenuity.



ONE HUNDRED MILLION WERE SUPPLIED—and rejects were negligible.

FIRING PIN

SMALLEST IN SIZE, the firing pin was the precision component that was supplied in the greatest volume by General Electric during the war. More than 100,000,000 plastics firing pins were delivered.

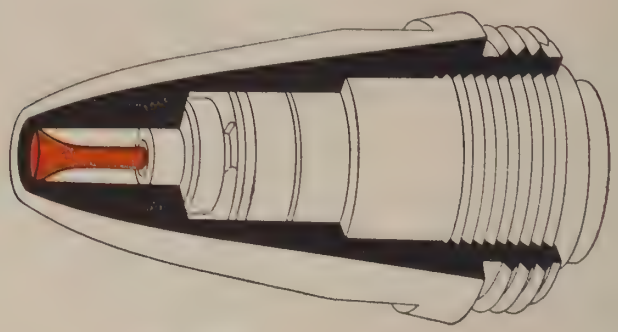
The plastics pin fits into the metal detonator of a 40-mm. Bofors anti-aircraft shell. The instant such a projectile touches a plane, the plastics pin is driven backward to detonate the explosive charge. A Bofors gun fires 120 shells a minute.

Three-dimensional precision

Precision of the pin was all-important. Over-all length had to be kept to a tolerance of 0.006 inch; the large "hammer" diameter

to 0.004; the small diameter to 0.005. These tolerances were attained by grinding the pin after the molding process.

Willys-Overland Motors, Inc., brought the problem of molding and grinding the plastics firing pin in huge quantities to General Electric's plastics plant in Fort Wayne. On the first order, General Electric built a 57-cavity mold to specification. G-E engineers questioned the design of the mold.



ACTUAL SIZE

Redesign of the mold

Before accepting another order for the plastics firing pins, General Electric insisted upon a redesign of the mold to produce pins with a vertical rather than a horizontal "flash." It had been difficult to hold the required precision dimensions in grinding pins from the original mold. It was felt that the new mold design would solve a serious reject problem.

A single-cavity mold was made on this principle at General Electric's expense. Ordnance was convinced, from actual testing, that pins from the redesigned mold gave better performance.

Tooling for mass production

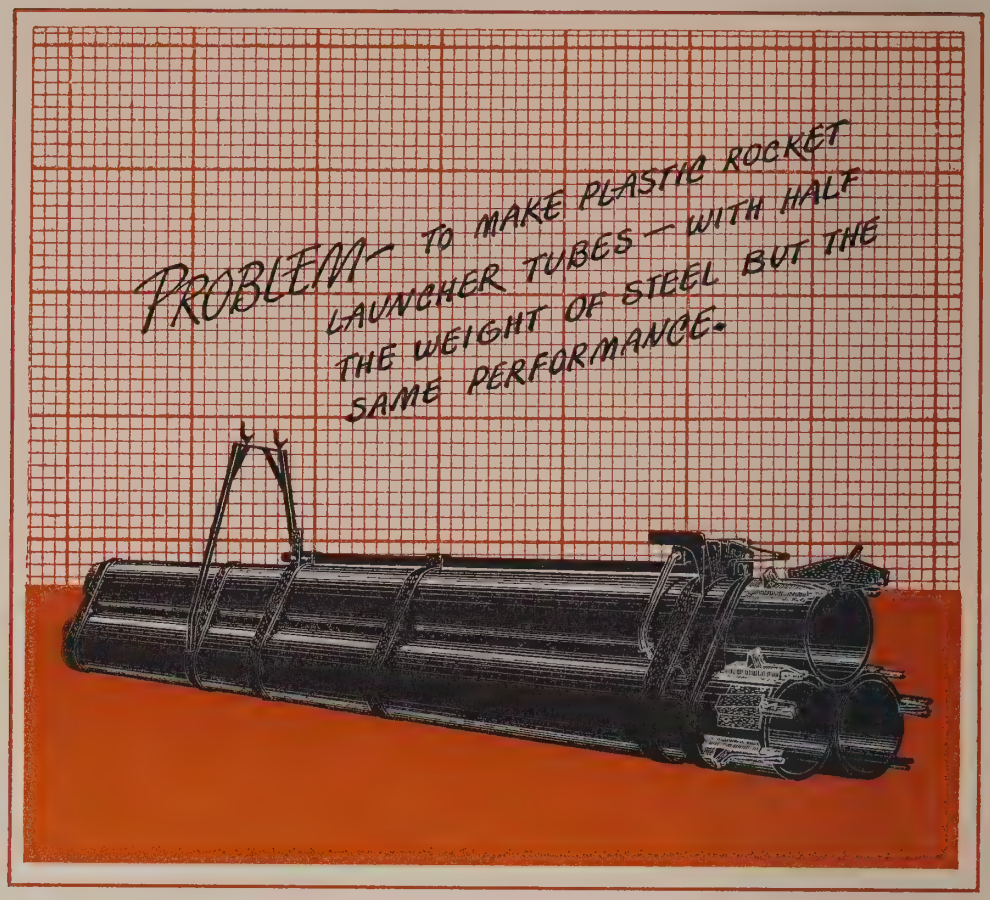
General Electric was authorized to build eleven 60-cavity molds to put the pin into volume production. Three automatic grinding machines were specially designed and built to process the pins to required precision after molding. It was possible to feed thousands of pins into a hopper, and they came out ready for inspection.

The material used was a standard wood-flour-filled phenolic. The process was compression molding.

General Electric worked up production at Fort Wayne to a rate of 1,500,000 a week. Only 576 man-hours a week went into this program. It was possible for only two operators to handle eight molds which were pressing three shifts a day. One operator could tend two automatic grinding machines which ran two shifts a day. And there were two inspectors for two shifts a day.

Plastics firing pins were packed 20,000 in a box and shipped to four makers of Bofors fuses—Willys-Overland Motor Corporation, Toledo; McGraw Electric Company, Elgin; Carter Carburetor Company, St. Louis; and Perfex Corporation, Milwaukee.

Mechanization and carefully planned tooling were more than justified in the production rate attained.



FOUGHT ON LAND, AT SEA, AND IN THE AIR. Some stood up under firing tests of more than twice U. S. Army Ordnance requirements.

ROCKET LAUNCHER TUBES

WHEN THE ROCKET first became an important weapon in the war, General Electric was asked to develop and manufacture a plastics rocket launcher tube. It had to be lightweight. It had to resist denting, if struck. And it had to stand up for at least 20 rounds of firing.

The firing characteristics of the 4.5-inch rocket, for a time, left something to be desired. And the first experimental plastics rocket launcher tubes—made of rolled paper impregnated with

phenolic resin—did not show up well in Ordnance tests.

Problem of paper

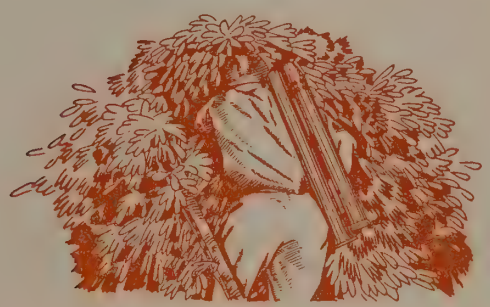
The trouble was with the paper. In co-operation with General Electric, the Byron Weston Company, prominent paper makers of Dalton, Massachusetts, developed a new rag-base paper that could be saturated with enough resin to give the tube the required mechanical strength. General Electric developed a new phenolic resin. Satisfactory tubes could then be laminated. They had good weathering characteristics, resistance to denting, and high strength, and were easy to manufacture in large quantities.

To attain an unheard-of production volume, General Electric designed and built 52 massive tube-rolling machines, devoting an entire plant to the job.

G-E plastics rocket launcher tubes have been used in 4-foot lengths by ground forces for jungle fighting in the Pacific . . . in 90-inch lengths for use with tanks and for landing craft in amphibious operations in both Europe and the Pacific . . . in 120-inch clusters for military aircraft on every front. How important the rocket was as a weapon to all branches of the service has not yet been fully told. But when it is, the plastics rocket launcher tube—half as heavy as steel for the same performance—will receive due credit.

Some G-E rocket launcher tubes have stood up under firing 47 rounds—more than twice the Ordnance requirement of 20 rounds.

This is another instance of working outside the immediate field of plastics—with the paper industry—to develop a satisfactory piece of war equipment.



NAVY PLASTICS PARTS

A MODERN BATTLESHIP can supply electric power to a city of 500,000. A great deal of electrical equipment is needed on every warship, from battlewagon to tin can.

The United States Navy is a customer of long standing of the Plastics Divisions of General Electric. During the Naval building program, which antedates the war, G. E. supplied scores of plastics parts to the Navy. These fall into these categories of electrical insulating parts: connection boxes, switch handles, spools, spacers, plug tips.

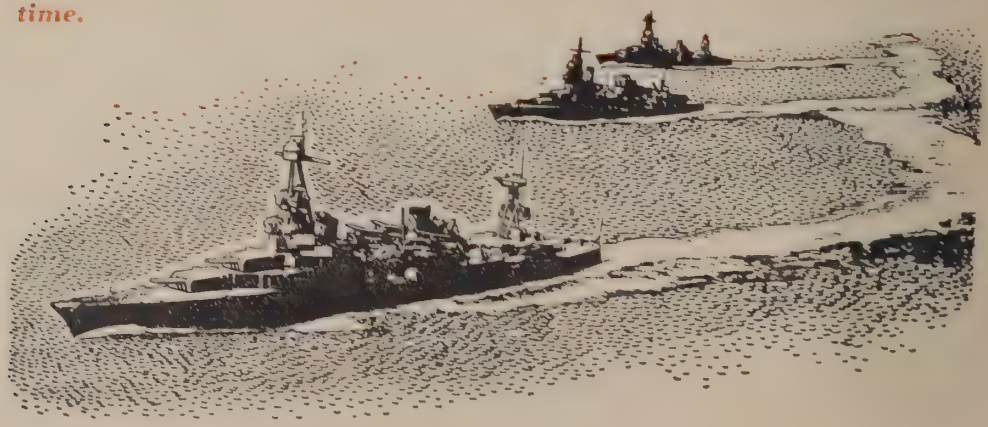
A famous set of plastics specifications

All electrical components made of plastics for the Navy are manufactured to a standard set of specifications. This "spec" sheet, which contains an unusual number of controls, has facilitated production.

G-E engineers find it necessary to make only occasional recommendations, so thoroughly do Navy designers know plastics.

Most of the G-E plastics parts for the Navy are compression-molded, with hand molds or molds that have semi-automatic accessories, from standard phenolics.

In this case, well-planned specifications set "ground rules" for an efficient manufacturing service. The Navy knew what it wanted—and got it every time.



RESIN—Raw Materials

PHENOL
G-E Material No. D5J5
Approved Sources 3
Acceptance Tests 8
- Color
- Pyridines
- Freezing Point
- Moisture
- Odor
- Ortho
- Phenol
- Distillation

FORMALDEHYDE
G-E Material No. D5Y7
Approved Sources 4
Acceptance Tests 7
- Acidity
- Formaldehyde
- Methanol
- Reactivity
- Sp. Gr. @ 20° C & 25° C
- Color
- Turbidity

AMMONIA
G-E Material No. D4B2
Approved Sources 2
Acceptance Tests 4
- Sp. Gr.
- Ammonia
- Color
- Residue

ACID
G-E Material No. D4A2
Approved Sources 4
Acceptance Tests 1
- Acidity

HEXA
G-E Material No. D5F2
Approved Sources 2
Acceptance Tests 6
- Ash
- Color
- Moisture
- Nessler
- Purity
- Screen

LIME
G-E Material No. D4B3
Approved Sources 1
Acceptance Tests 5
- Ash
- Color
- Moisture
- Screen
- $Ca(OH)_2$

TALC
G-E Material No. D4E7A
Approved Sources 2
Acceptance Tests 7
- Ash
- Moisture
- Acetone Extraction
- Bulk
- Oil Absorption
- Screen
- pH

STEARATE
G-E Material No. D5D36
Approved Sources 6
Acceptance Tests 3
- Ash
- Color
- pH

The Navy knew what it wanted. This material control chart set ground rules that expedited delivery of plastics parts.

Manufacture

DRY RESIN
G-E No. 3216
Type 1P1 (1st Step)
Processing Control 8
- Weights
- Time
- Temperature
- Power
- Pressure
- Vacuum

Chemical Tests
- Reactivity
- Flow Point

Final Control 1
- Flow Point

G-E No. 1358
Type 1P7 (2nd Step)
Final Control 4
- Flow Point
- Cure
- Screen
- Color

LIQUID RESIN
G-E No. 1181
Type 2P48
Processing Control 8
- Weights
- Time
- Temperature
- Power
- Pressure
- Vacuum

Chemical Tests
- Reactivity
- Flow

Final Control 4
- Viscosity
- Sp. Gr.
- Solids
- Acetone Solubility

VARNISH
G-E No. 1180
Type 2P2
Processing Control 8
- Weights
- Time
- Temperature
- Power
- Pressure
- Vacuum

Chemical Tests
- Reactivity
- Flow Point

Final Control 4
- Viscosity
- Sp. Gr.
- Solids
- Acetone Solubility

COMPOUND—Raw Materials (Other than Resin and/or Varnish)

WOOD FLOUR
G-E Material No. D5Y2
Approved Sources 3
Acceptance Tests 7
- Ash
- Bulk
- Acetone Extraction
- Moisture
- Oil Absorption
- Screen
- Color
- pH
- Iron

ASBESTOS
G-E Material No. D4E11A
Approved Sources 3
Acceptance Tests 9
- Ash
- Bulk
- Acetone Extraction
- Grit
- Moisture
- Oil Absorption
- Screen

DIATOMACEOUS EARTH
G-E Material No. D4E13A
Approved Sources 1
Acceptance Tests 6
- Ash
- Bulk
- Acetone Extraction
- Moisture
- Oil Absorption
- Screen

MICA
G-E Material No. D4E12
Approved Sources 1
Acceptance Tests 7
- Ash
- Acetone Extraction
- Moisture
- Bulk
- Oil Absorption
- Screen
- pH

FABRIC CUTTINGS
G-E Material No. A2A13B
Approved Sources 2
Acceptance Tests 5
- Color
- Moisture
- Ash
- Cleanliness
- Size

FABRIC FLOCK
G-E Material No. A2A12B
Approved Sources 3
Acceptance Tests 8
- Color
- Moisture
- Ash
- Cleanliness
- Bulk
- Oil Absorption
- Acetone Extraction
- Fineness

DYE
G-E Material No. D5G2A
Approved Sources 4
Acceptance Tests 7
- Ash
- Color
- Acetone Extraction
- Moisture
- Screen
- Dispersion
- Odor

PIGMENT
G-E Material No. D4C16
Approved Sources 2
Acceptance Tests 5
- Ash
- Color
- Moisture
- Screen
- Acetone Extraction

WAX
G-E Material No. D5D20
Approved Sources 2
Acceptance Tests 3
- Cleanliness
- Freezing Point
- Color

ASBESTOS CLOTH
G-E Material No. A2E1C
Approved Sources 3
Acceptance Tests 6
- Asbestos Content
- Iron
- Thickness
- Weight
- Breaking Strength
- Construction

Manufacture

DRY RESIN TYPE
Processing Control 10
- Weight
- Time
- Temperature
- Power
- Pressure

Physical
- Plasticity
- Cure
- Appearance
- Color
- Screen

Final Control 25
- Apparent Density
- Pourability
- Screen
- Plasticity
- Cure
- Impact Str.
- Flexural Str.
- Modulus of Elasticity
- Tensile Str.
- Compressive Str.
- Shrinkage
- Heat Distortion
- Water Absorption
- Sp. Gr.
- Dielectric Str.
- Power Factor
- Dielectric Constant
- Loss Factor
- Arc Resistance
- Conductivity
- Moisture
- Ash
- Acetone Extraction
- Hardness
- Flame Resistance

LIQUID RESIN TYPE
Processing Control 10
- Weight
- Time
- Temperature
- Power
- Pressure

Physical
- Plasticity
- Cure
- Appearance
- Color
- Screen

Final Control 25
- Apparent Density
- Pourability
- Screen
- Plasticity
- Cure
- Impact Str.
- Flexural Str.
- Modulus of Elasticity
- Tensile Str.
- Compressive Str.
- Shrinkage
- Heat Distortion
- Water Absorption
- Sp. Gr.
- Dielectric Str.
- Power Factor
- Dielectric Constant
- Loss Factor
- Arc Resistance
- Conductivity
- Moisture
- Ash
- Acetone Extraction
- Hardness
- Flame Resistance

VARNISH TYPE
Processing Control (Treating) 6
- Weight
- Time
- Temperature

Chemical
- Resin Content
- Volatile Content
- Acetone Solubility

Processing Control (Treated) 3

Chemical
- Resin Content
- Volatile Content
- Acetone Solubility

Final Control 24
- Bulk
- Size
- Plasticity
- Cure
- Impact Str.
- Flexural Str.
- Modulus of Elasticity
- Tensile Str.
- Compressive Str.
- Shrinkage
- Heat Distortion
- Water Absorption
- Sp. Gr.
- Dielectric Str.
- Power Factor
- Dielectric Constant
- Loss Factor
- Arc Resistance
- Conductivity
- Moisture
- Ash
- Acetone Extraction
- Hardness
- Flame Resistance

Molding

Special Tickets on Press — Special Tags on Compound Containers — Control Tests 4: Acetone Extraction, Ash, Sp. Gr., Water Absorption

Finishing and Inspection—Parts Go to a Separate Finishing Section

Final Inspection 9
- Acetone Extraction
- Sp. Gr.
- Ash
- Water Absorption
- Hi Pot
- Power Factor
- X Ray
- Special Mechanical Tests (Drop Test, etc.)
- Special Inspection and Stamping (Navy, etc.)
- Packing and Shipping

FLAME-RESISTANT MOLDED AND LAMINATED PLASTICS

THE BURNING of the *Normandie* dramatized, among other things, the need for molded and laminated plastics insulating parts that resist flame. Burning power and light control panel-boards—made of cotton-base laminates—were a serious problem.

The Bureau of Ships, Navy Department, instituted the development of new flame-resistant plastics materials for molded and laminated parts. Such materials, the Navy said, would introduce a new margin of safety to fighting ships—especially submarines.

Along with other suppliers of electrical equipment for the Navy, General Electric served on the Navy Panel Board Committee, appointed to study these problems of plastics inflammability. General Electric's contribution was to co-operate with the Bureau and industry in all phases of the project—including the development, evaluation, application, and manufacture of improved materials.

Development of glass fabric and melamine resin laminate

A composition of glass cloth and melamine proved to be the best available material. It had the electrical properties required for ordinary power frequencies—excellent mechanical strength—and the desired resistance to flame.

This new laminate was applied to more and more power and light insulating panel-boards and parts for fighting ships.

Development of G-E Compound 1423

It took longer to evaluate than to develop a flame-resistant molding material. Motion pictures were taken to show how it stood up against an acetylene torch—in contrast with the shattering and burning of paper- and cotton-filled phenolic materials.

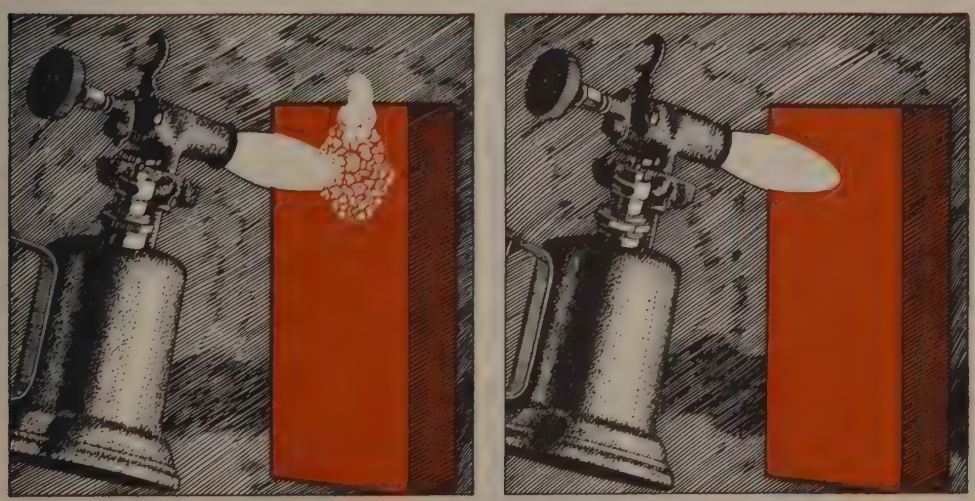
Now there are four flame-resistant G-E molded plastics—

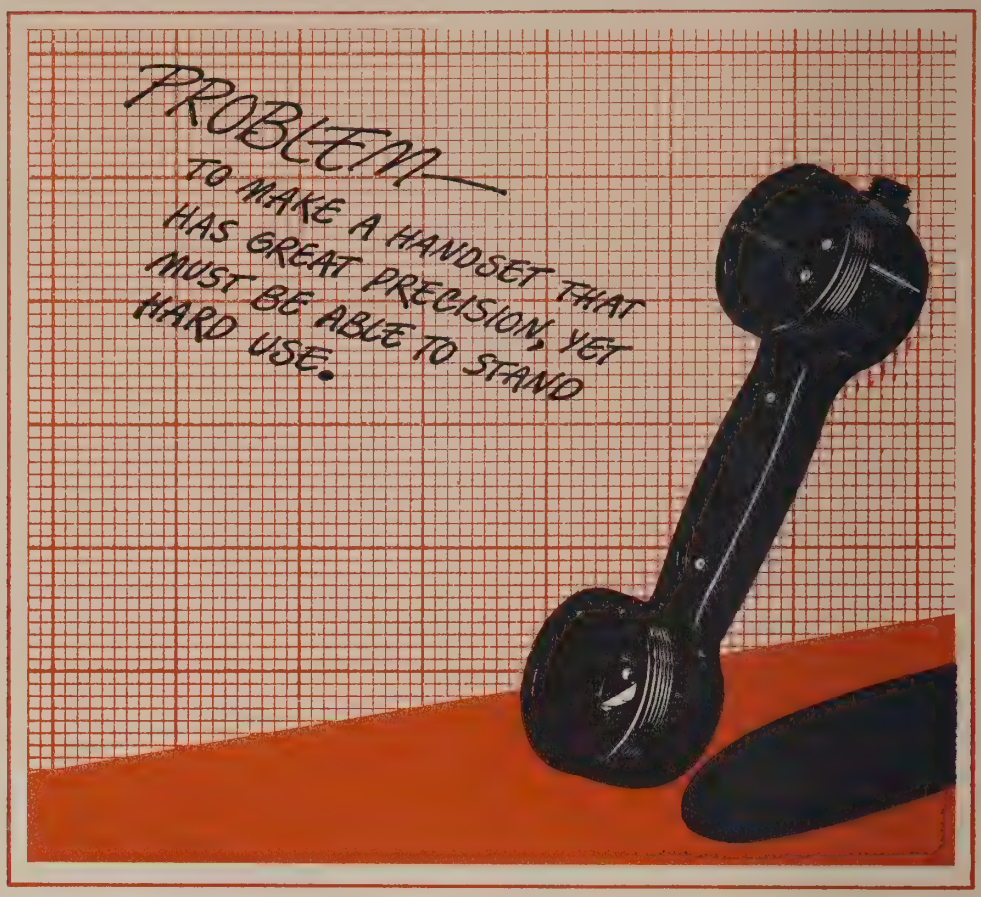
two developed during the war. Flame resistance is attained by impregnating inorganic asbestos fabric with phenolic resin. And this is done without adverse effect on moldability, electrical properties, resistance to moisture and chemicals, or mechanical strength. In fact, there is some evidence that mechanical strength is actually improved.

An interesting problem arose in connection with asbestos. It was found that asbestos had to be woven into fabric first and then chopped to give the requisite mechanical strength. Unwoven asbestos just wouldn't do the job. It took a good deal of persuasion to convince even asbestos men that their material had to be woven to specification only to be chopped up for plastics filler later. Yale University cooperated with G.E. in conducting tests to determine the toxicity of gases given off by various materials when subjected to high temperatures.

An increasing number of uses for this new molding material have been found for all kinds of switchgear aboard Naval vessels: as insulation for propulsion equipment; in circuit breakers; instrument meter frames; bus bar supports; electrical fuse boxes.

It is expected that these flame-resistant materials will find peacetime applications for switchgear in heavy industry, where their much greater cost is justified for reasons of safety. At present the molded material costs about six times as much as conventional cotton-filled phenolic.





"SOUND-POWERED" TELEPHONES that needed no batteries or other outside power.

SOUND-POWERED TELEPHONE

ONE OF THE INGENIOUS DEVELOPMENTS brought into quantity production during the war is the sound-powered telephone. It is so named because magnetic motor parts convert vocal energy into a low-voltage current that is reproduced as sound at distances of up to and exceeding 30 miles. No batteries or other outside power is needed. Just connect two of them together with a pair of wires—and talk. No worry about power failures—that meant a lot wherever battles were fought.

The molding of the many plastics parts for a sound-powered

telephone, with their numerous small metal inserts, required a combination of exacting precision and ruggedness. General Electric has been successful in supplying such plastics parts.

RCA sound-powered telephone

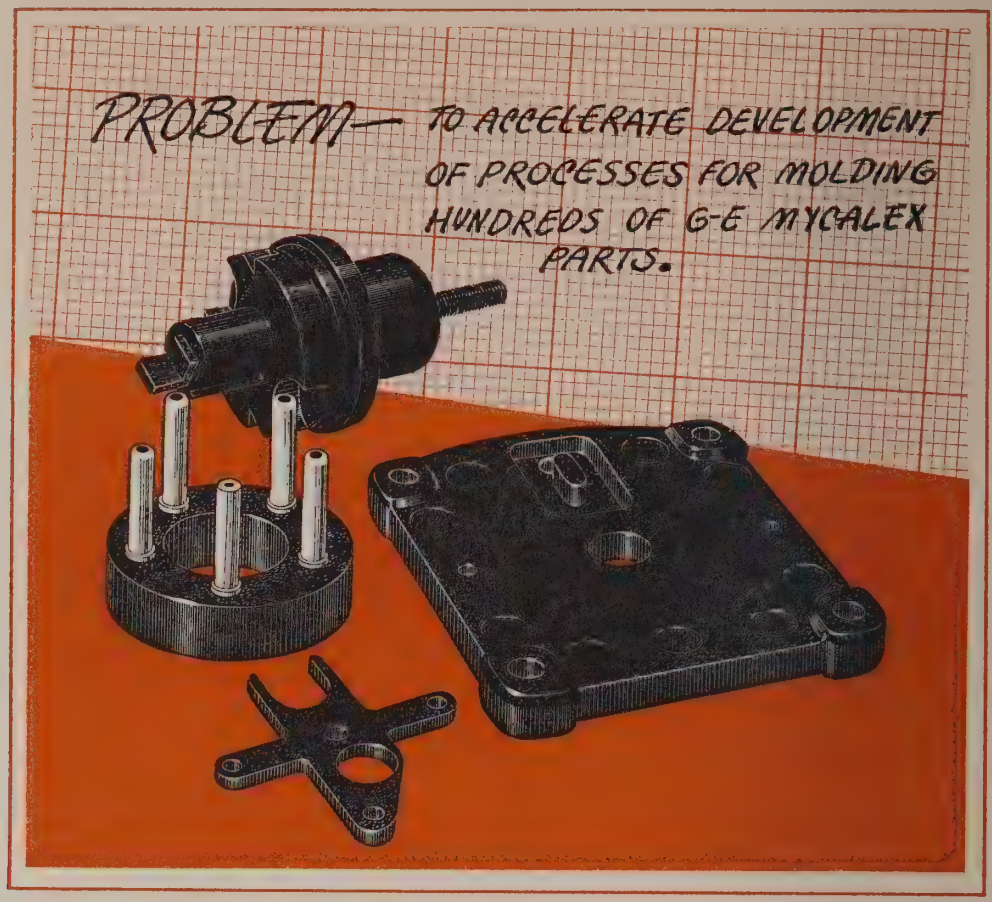
Twenty-four different plastics parts—including receiver cases, motor backs, motor bases, mouthpieces, and coil spools—go into sound-powered handsets and headsets, made by the Radio Corporation of America. The problem was to mold small metal parts accurately into place—on a production basis.

Owing to the severe service required of them, all parts had to be exceptionally strong and rugged. One test of a finished RCA sound-powered telephone handset is to drop it down a 6-foot chute at an 80-degree angle onto concrete-backed, tempered Masonite.

G.E. found a fabric-filled phenolic molding compound that had the required mechanical and impact strength to take such punishment.

Then the problem was to maintain dimensional stability of all parts. For critical parts of the sound-powered telephone, General Electric developed a special slow-baking process to reduce plastic shrinkage to a minimum. These parts were baked for 76 hours after the molding process, with periodical coolings.

This case illustrates how tough—and at the same time dimensionally stable—precision plastics parts can now be made.



SOME OF THE MANY VITAL PARTS—molded of G-E mycalex for jobs no other material could do.

G-E MYCALEX PARTS

A COMPOUND of glass and powdered mica, G-E mycalex has superior resistance to arcing and high temperatures—along with good mechanical strength.

Before the war, this insulating material was only available in simple compression-molded shapes and standard sheets and rods. Because of its hardness, machining into more intricate shapes was a difficult, costly, and time-consuming operation.

The Plastics Divisions undertook to develop methods of

transfer- and injection-molding G-E mycalex. And, by 1941, the first of such parts were being produced on crudely adapted presses. Moldability, dimensional stability, and anchorage for metal inserts give G-E mycalex a unique combination of properties.

Molding mycalex—an important development

Seeing wide potential applications, General Electric developed new molds, new methods of heating them, and new equipment such as presses and pre-heating and annealing ovens. At the same time, the General Electric Laboratories developed compounds of G-E mycalex that would make stronger molded parts with less molding pressure.

All of this developmental work was more than justified by the great wartime demand for hundreds of different kinds of mycalex parts. There were some applications where only mycalex would do the job, and G-E mycalex proved to be a superior insulation wherever it was used. There are two broad fields of application for G-E mycalex: 1) for electrical insulation where arc-over and high temperatures are critical; 2) where high-frequency, high-temperature insulation is required in radio and radar equipment.

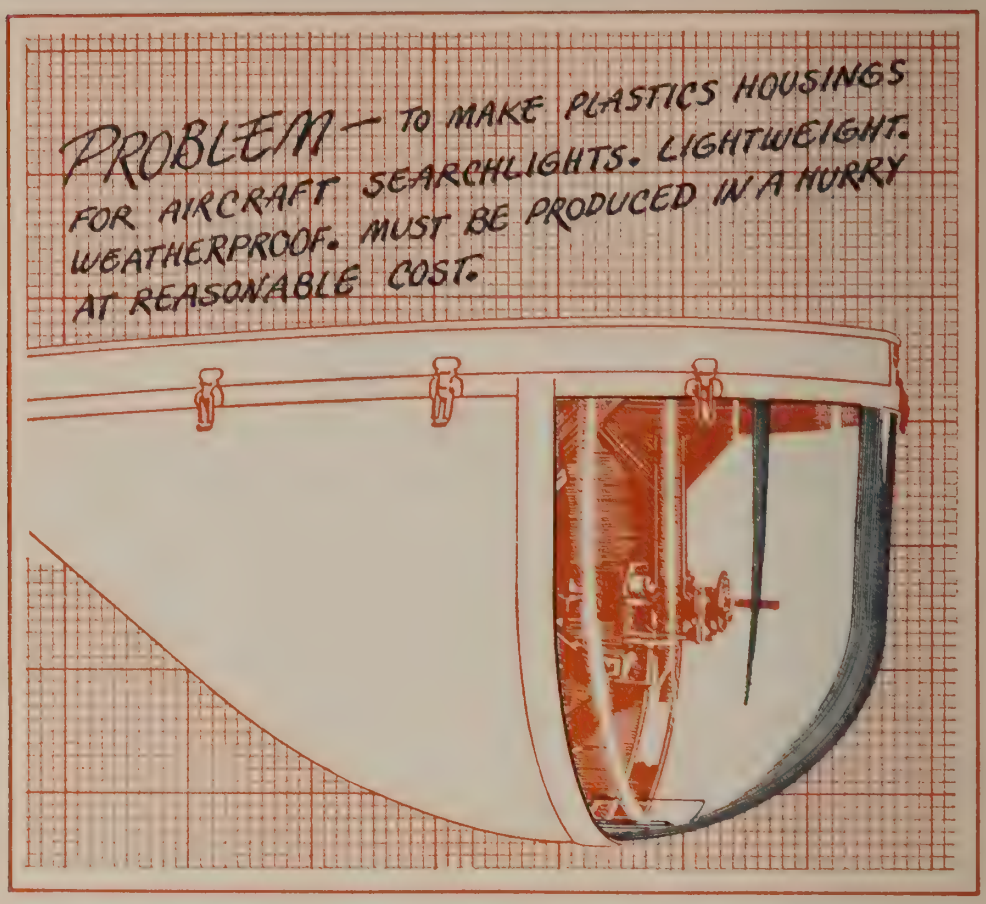
Where molded mycalex parts are used

Improvements in techniques and equipment have resulted in production records. An outstanding example is the G-E mycalex terminal sleeve for aircraft engine ignition systems. It has overcome many difficulties that had been encountered with other materials at high altitudes and in the tropics. More than 16,000,000 terminal sleeves have been turned out by the Plastics Divisions for our warplanes.

The mycalex aircraft ignition terminal sleeve

This is an interesting case of technical "activation" of a material that had been known for 20 years, for vital war applications.

G-E MYCALEX TERMINAL SLEEVE—the contact spring is riveted in.



PLASTICS "EYES" FOR PATROL BOMBERS . . . spotted the enemy in the dark.

AIRCRAFT SEARCHLIGHTS

PATROL BOMBERS needed powerful searchlights to illuminate radar-detected targets. They had to be light enough to carry under the starboard wing. They had to have aerodynamic smoothness. They had to withstand weather and temperature conditions encountered on sea patrol. A difficult shape had to be produced in a hurry at a reasonable cost.

These requirements suggested the use of low-pressure laminated molding techniques.

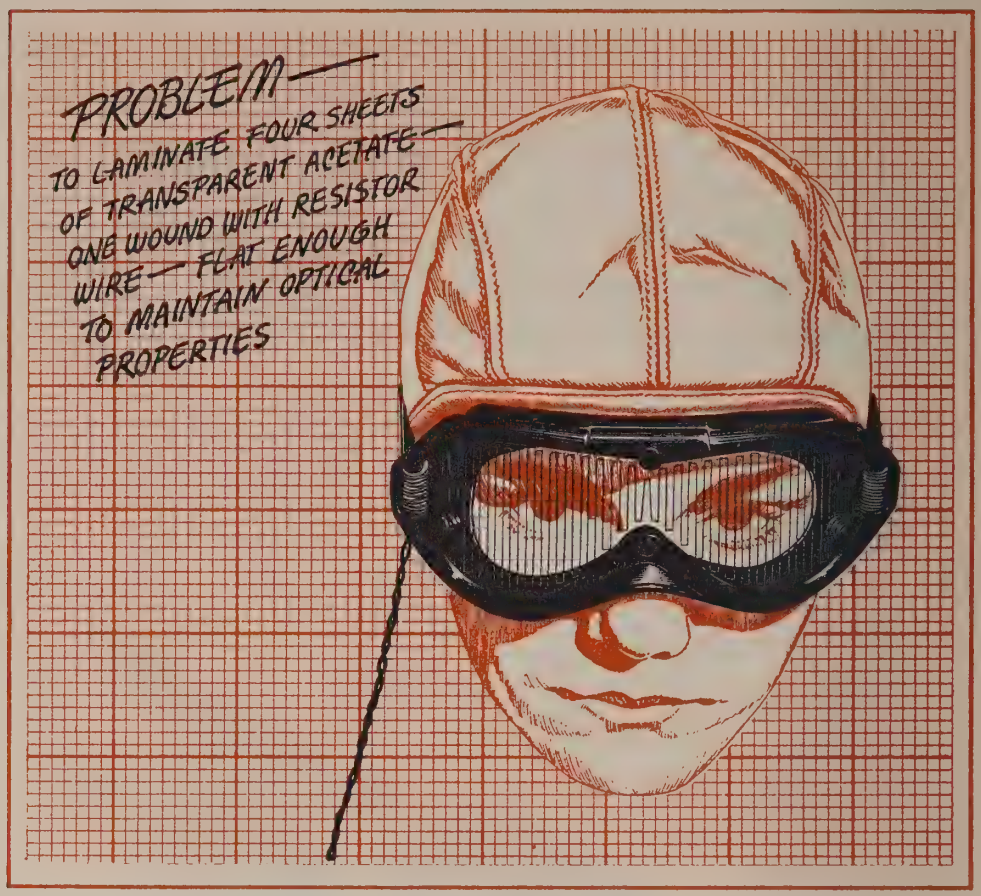
A simple, lightweight mold was produced quickly. Sheet steel

parts, some spun, some shaped by hammering, were welded together to form the mold within the time allotted.

Cotton fabric impregnated with G-E 3203 liquid phenolic resin was utilized to give the finished housing its needed characteristics, strength, lightness in weight, resistance to temperature and weather variations.

To get aerodynamic smoothness, laboratory technicians developed a special formulation for the face sheets. The skin panel, by simple painting, could be given the desired color.

This case illustrates the ability to tool up and get into production quickly on large plastics parts—and the ability to vary formulations to meet specific requirements.



LAMINATED 500,000 HEATED PLASTICS GOGGLES—and met rigid optical requirements.

HEATED GOGGLES

EYES, TOO, had to have protection against the sub-zero cold of high altitude flying. So the development of heated goggles became a vital part of the Flying Suit Program.

How to heat goggles for flyers

Goggles containing a zig-zag of resistor wire that could be hooked up to the flyer's 24-volt current were designed. And it was decided that they would be most effective if made of heat-conducting plastic.

The problem was to laminate four sheets of transparent acetate, one of which was wound with the proper length of resistor

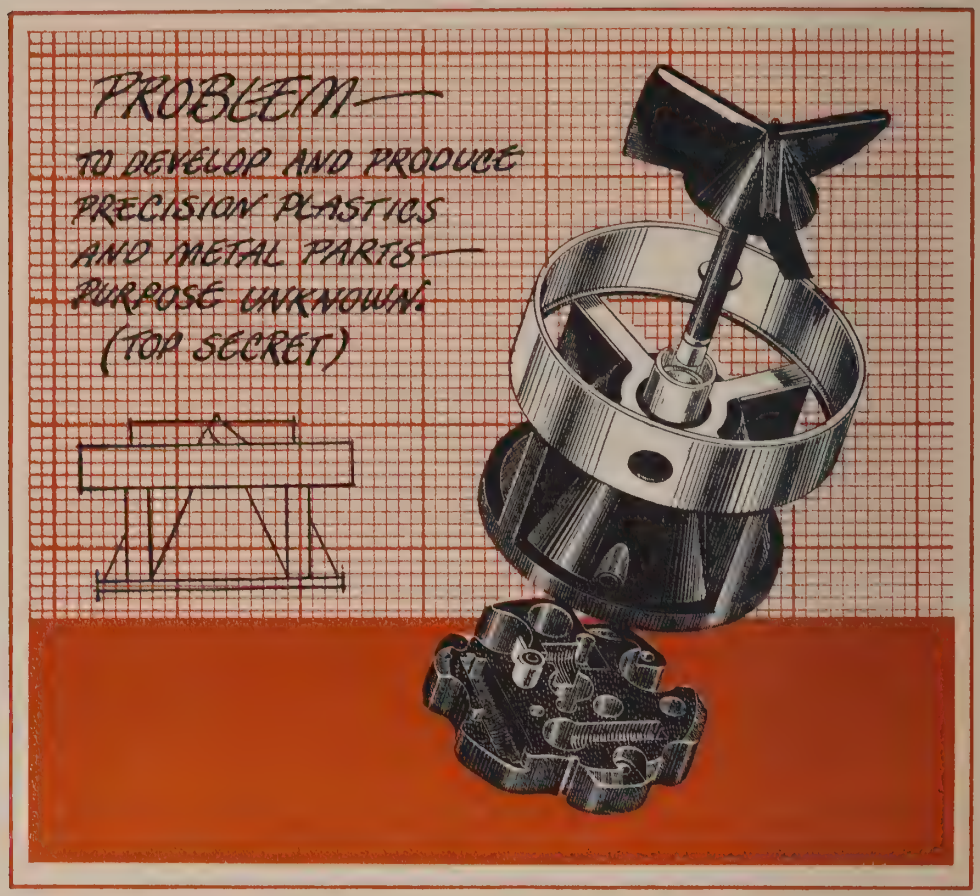
wire, and still maintain optical properties. There could be no "flow" in the plastics material to distort the vision of the wearer.

Rolled nickel press plates gave needed flatness

This called for perfect flatness in the finished goggles. General Electric solved the problem by making special press plates of rolled nickel and by split-second control of the lamination process. Laminated on these special plates, plastics goggles came up to optical requirements. And General Electric supplied more than half a million to our Air Forces.

In optical production, dust of course is anathema. Ingenious methods of protecting materials from particles of foreign matter were devised.

This is an interesting example of how transparent plastics may be utilized for a special optical job.



SECOND ONLY TO THE ATOMIC BOMB. Plastics helped make the Proximity Fuse that "all but thinks."

PLASTICS PARTS FOR THE PROXIMITY FUSE

THE VT (Variable Time) or Proximity Fuse was as well kept a war secret as the atomic bomb—and ranks next to that epoch-making weapon as an Ordnance project.

It is an "all-but-thinking" fuse that works on an electronic principle. Unlike contact or delayed action fuses, which explode their charge mechanically, the Proximity Fuse "feels its way" by means of

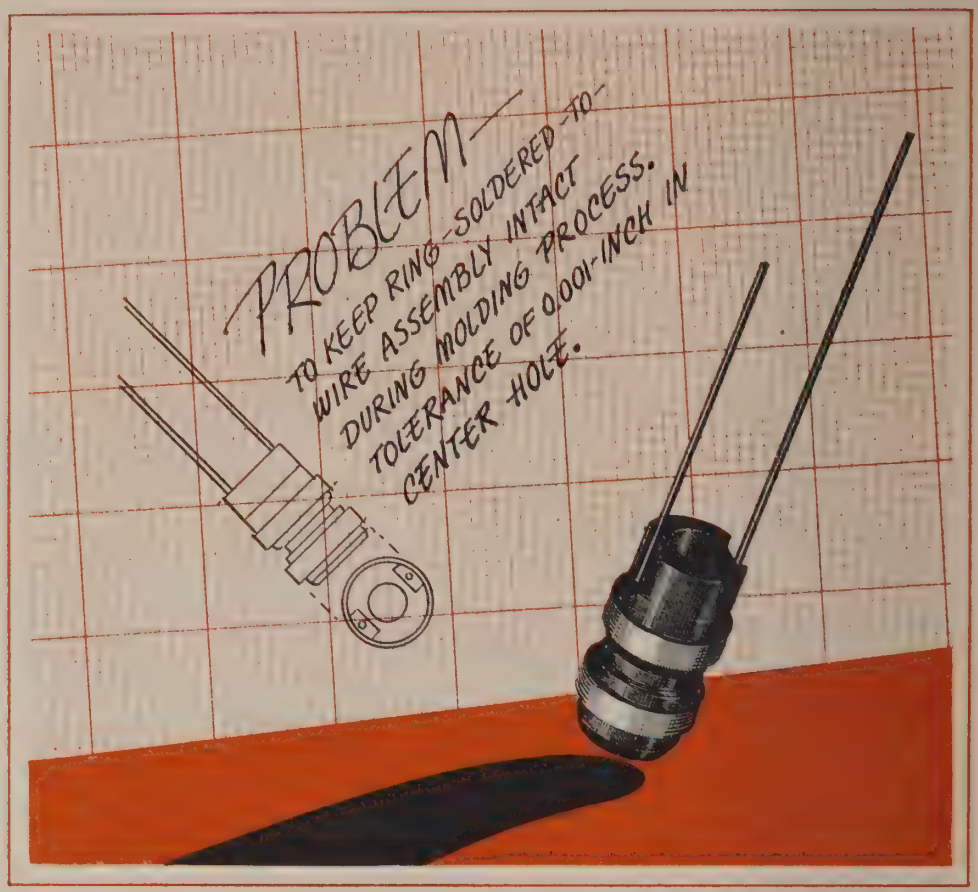
radio wave and explodes when it approaches its target. That serves to convert a "near miss" into a bull's-eye.

Without knowing what they were intended for, General Electric engineers developed the four plastics components that went into the Proximity Fuse. Extremely close tolerances and a specified life expectancy of fifty seconds made the job a mystery.

There were three stages in the development of parts. It was necessary for the Plastics Laboratories to compound an entirely new low-loss material. Heartbreaking difficulties were encountered in molding in the heavy metal insert for the radio chassis.

Finally all the bugs were worked out in redesign of the four parts delivered—nose, radio chassis, interruptor, and rotor cup. And so sound had been the developmental work that it was possible to keep ahead of schedule even when the original production rate was multiplied six times.

General Electric engineers established a production record with practically no rejected parts.



MOTOR "NERVES" FOR WARPLANES—Plastics solve a ticklish problem.

RINGS FOR SELSYN MOTORS

A SELSYN MOTOR stops and starts according to electrical impulse. Its rotor is an accurate recorder. Selsyn motors might be called the co-ordinating nerves of a warplane, for they synchronize vital instrument and weapon controls. Some 82 of these precision instruments are installed in the gun turret of a B-29.

General Electric was a major supplier of plastics parts for selsyn motors. Transfer-molding the complex rotor on a mass production scale presented the most interesting technical problem.

Silver contact rings—later alloyed with platinum to meet

certain high-altitude operating conditions—are soldered to fine Formex wire. This assembly had to be molded into a cotton-flock-filled phenolic—the rings accurately aligned, the wire imbedded so as not to become exposed even by so much as a pin point after precision-machining of the entire rotor.

Every rotor had to pass its own Hi-pot test—2500 volts for a minute.

Much was learned about precision molding and inspection on a mass production scale from this experience. And General Electric was able to help other manufacturers solve selsyn motor production problems.

PLASTICS GAVE VOICE TO OUR FLEET. General Electric knows the secret of making molded laminated loud-speaker diaphragms with excellent acoustical properties.

DIAPHRAGMS FOR LOUD-SPEAKERS

ALL TOO OFTEN the loud-speaker system of a warship, after the firing of big guns, fell silent just when it was needed most to broadcast battle commands to the crew. Speaker diaphragms made of paper and aluminum were too delicate to withstand the blast.

The problem was brought to General Electric. Maybe blast-resistant speaker diaphragms could be made of plastics. There were

a number of problems to be overcome.

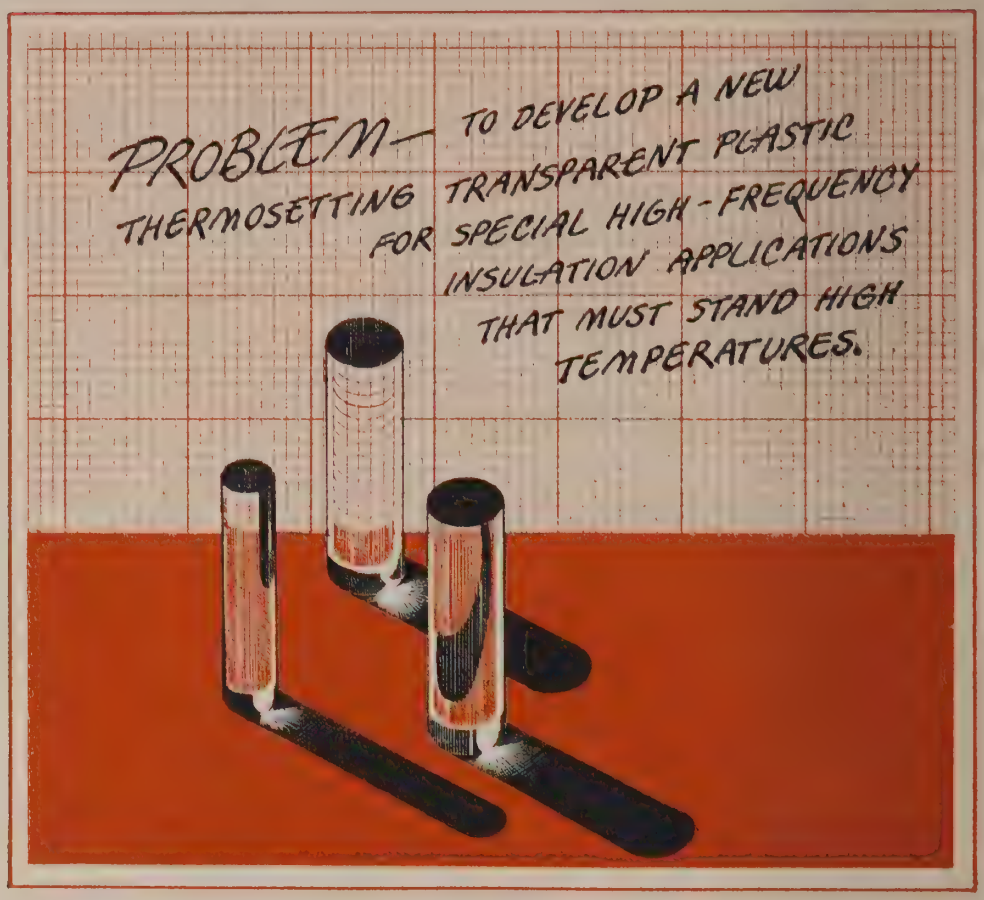
Solving the "draw" problem

The domed contour of a typical diaphragm necessitated a severe draw on material during the molding process. This problem was solved by highly specialized treating and molding techniques. The process is still secret.

G-E plastics speaker diaphragms are now available in a number of sizes and in thicknesses ranging from 0.003 to 0.02 inch. Such a part is molded to tolerances of 0.0005 inch. Because weight influences acoustics, weight requirements are held within a few tenths of a gram.

Molded, laminated cloth-base phenolic resin diaphragms offer not only blast-resistance but other important advantages: long life at high temperatures, resistance to humidity, and excellent acoustic properties for voice. The voice coil is mounted on the diaphragm to transfer vibration of sound waves. High frequency and vibrations cause high temperatures, so the diaphragm is backed by aluminum to dissipate this heat and keep the diaphragm from burning.

This wartime development is bound to have ever-wider peacetime application. Already new plastics speaker diaphragms have been installed in public address systems that serve ball parks and railroad and subway stations. The greater durability of plastics speaker diaphragms—attained without any sacrifice of acoustical quality—recommends their use for all public address systems.



THE NAVY SPECIFIED IT AS AN OUTSTANDING MATERIAL TO USE FOR RADAR. Came straight from the laboratory.

G-E COMPOUND 1421

THERMOPLASTIC MATERIALS like conventional polystyrene did not have enough heat resistance in certain new high-frequency electrical insulation applications—radar, for example, where high temperatures had to be met during soldering operations in the assembly of the unit.

General Electric Plastics Laboratories made a significant contribution to the war effort with the development of G-E Compound 1421 to solve this problem. This new plastic material is as

transparent and practically as good electrically as polystyrene, but is thermosetting. G-E Compound 1421 doesn't liquefy up to 250 C, whereas polystyrene will be permanently distorted at temperatures around 110 C.

Usefulness of G-E Compound 1421 to radar

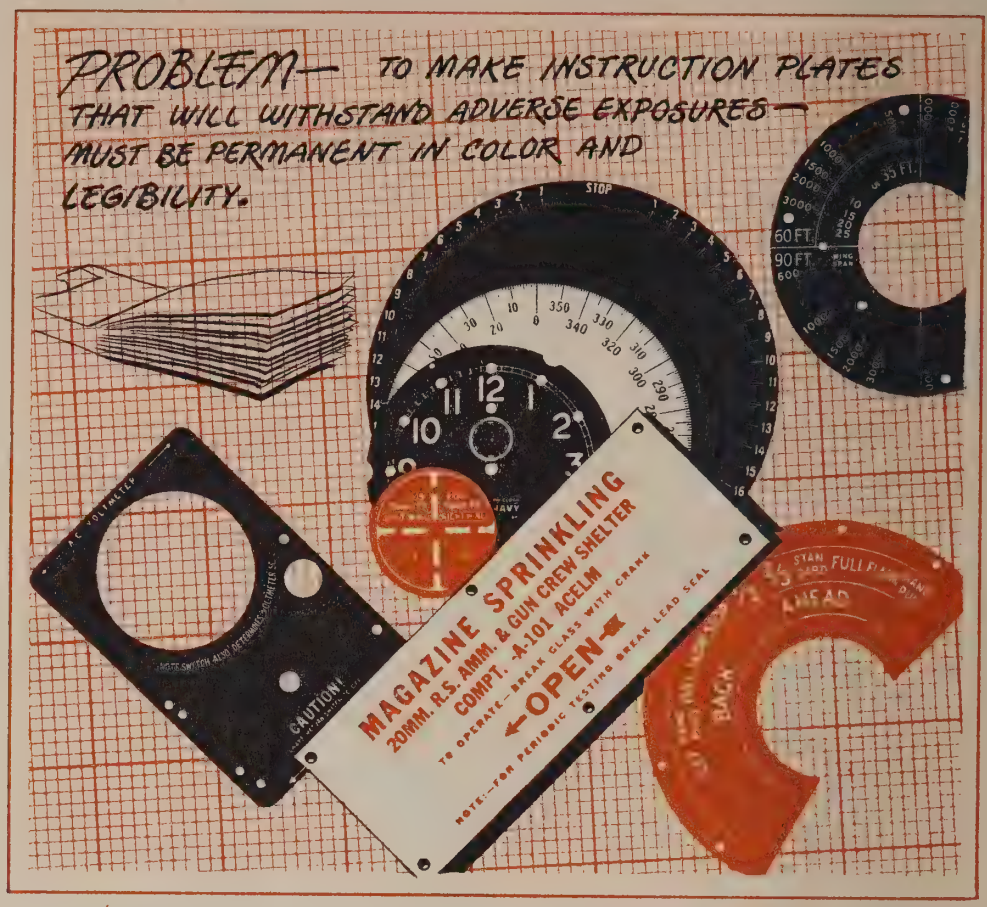
That is why G-E Compound 1421 was designated as the insulating material for new radar equipment and was used to replace other insulation in existing equipment.

G-E Compound 1421 was supplied almost immediately—long before the usual time that elapses between laboratory development and commercial production.

Monsanto Chemical Company co-operated in developing one of the ingredients for the compound for large scale production. The G-E Plastics Laboratories have continued to make improvements in G-E Compound 1421.

This compound has been made available in rods and plates which can be machined as readily as brass to required dimensions. Since the Navy specified it as an outstanding material to use for special radar insulating applications, G-E Compound 1421 has been produced for over 100 radar subcontractors.

This was a case of compounding a material to meet a specific requirement and of speeding up production to meet a vital production schedule. G-E Compound 1421 is expected to prove a valuable material for postwar television equipment.



SO THEY COULD ALWAYS READ "LIFE-AND-DEATH" INSTRUCTIONS. Plastics proved superior to other materials for hundreds of instrument and weapon control dials, charts, and instruction plates.

NAMEPLATES AND INSTRUCTION PLATES

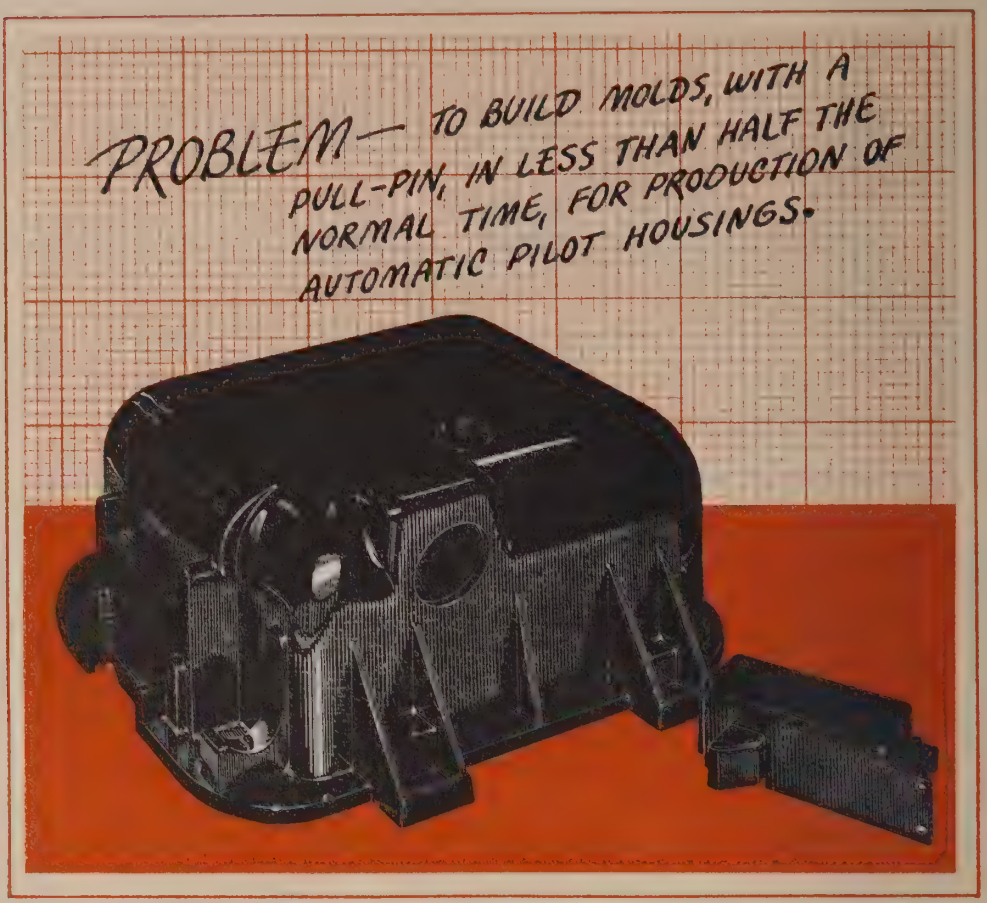
G-E LAMINATED TEXTOLITE nameplates and instruction plates were originally developed as replacements for scarce non-ferrous metals—and have made the replacement good for war and probably for peace. For this material has proved itself superior to other materials for hundreds of instrument and weapon control dials, charts, and instruction plates.

There are many advantages in these uses of G-E laminated Textolite. Such plates are permanent . . . have improved legibility . . . cost less. They can present, more clearly and accurately, detailed information such as intricate wiring diagrams. And they have good electrical insulating value for direct use on almost every type of equipment.

G-E laminated Textolite may incorporate a printed sheet of paper in its sandwich of materials. Indelible inks in practically every color are now available. General Electric was responsible for instituting research in these inks and papers that stand up under the high temperatures of the laminating process.

G-E laminated Textolite may also be engraved or embossed.

This wartime development promises to have a widespread peacetime application to make postwar products better . . . less expensive to manufacture . . . safer . . . easier to use . . . more colorful.



AIRTIGHT PLASTICS PROTECTION FOR A STEEL AIRMAN. Mold-making records broken.

AUTOMATIC PILOT HOUSING

GENERAL ELECTRIC'S DELIVERY of an acceptable sample of an automatic pilot housing broke all records in mold making, and won an official commendation for speed.

Normally it would have taken from ten to twelve weeks to produce a mold for this part—a mold that included a pull-pin for molding in a two-inch hole. But General Electric was able to submit samples taken from a mold in less than five weeks.

The automatic pilot housing was compression-molded from

high-impact rag-filled phenolic G-E Compound 1379, a Navy-approved material.

After 20 holes were drilled and tapped in the molded piece, it had to be made airtight to protect the delicate mechanism of the automatic pilot.

This job also included five compression-molded parts—all delivered within 6 weeks.

This is typical of many rush jobs successfully tackled by General Electric during the war.

FUNGUS-RESISTANT PLASTICS

PLASTICS that contain cellulose are subject to attack by fungus in the tropics. Coating plastics with lacquer proved to be unsatisfactory, because it flaked off the smooth surfaces.

The Signal Corps Tropicalization Project asked General Electric to find a fungicide that could be mixed into plastic molding compounds, without affecting electrical properties and mechanical strength.

The General Electric Plastics Laboratories screened out hundreds of possible fungicides. Of eight likely candidates, only one filled the bill. This chemical, mixed into molding compound, makes a plastics part resistant to the creeping of tropical fungus. It constitutes only a very minor percentage by weight of the molding compound and does not have an adverse effect upon plastics properties.

As yet fungicidal plastics have not gotten beyond the developmental stage and have not been applied to war equipment, but it is a war development that will have broad future application—even in temperate climates, to combat mildew. It is expected that the cost of including fungicide will be so slight that it can be absorbed by the plastics manufacturer.

CONCLUSION

THE PLASTICS INDUSTRY doubled its volume of production every five years before the war. And during five years of war, its rate of growth was greatly accelerated. But more significant than this phenomenal wartime increase in production have been developments of new materials, new manufacturing processes, and new concepts of the usefulness of plastics in the world. For plastics have peacetime potentialities that are already beginning to be realized.

In 24 case histories, we have attempted to sketch details of some General Electric developments in the field of plastics. Let's summarize some of the new things in plastics now emerging from war production . . .

New materials

- Glass cloth impregnated with melamine . . . for laminated plastics that resist flame . . .
- Asbestos-cloth-filled phenolic . . . for molded plastics that resist flame . . .
- Plastics that resist fungus and mildew . . .
- Synthetic hard rubber that can be vulcanized and molded like plastics . . .
- New grades of G-E mycalex . . . leadless frit with a third less weight . . .
- G-E Compound 1421 . . . a transparent insulating material with high heat-resistance . . . for radar during the war . . . for television after the war . . .
- Inks and papers that retain legibility and color under high laminating heat . . . for more colorful and readable nameplates and instruction plates . . .
- Aluminum alloyed close to the expansion and contraction of plastics material . . . for molded-in metal inserts that won't crack away . . .

New manufacturing processes

- Industrial electronics has revolutionized the plastics industry. Electronic pre-heating now means less mold investment and maintenance . . . lower molding pressures . . . shorter cycles . . . faster cures . . . faster molding closings. Electronic controls have speeded inspection of finished plastics parts.
- Transfer-molding techniques have been perfected to the point where plastics products, once fabricated, can now be molded . . . with a saving in cost . . . to produce better plastics parts.
- Injection- and transfer-molding of G-E mycalex has been improved and mechanized . . .
- In many cases, it is now possible to get the same mechanical strength and electrical properties from plastics parts with lower molding pressures . . .
- High degree of mechanization of molding processes . . . new tools . . . new automatic mold accessories . . .
- Molds with longer draws . . . deeper "throats" . . .
- More complex molds . . .
- Improved hobbing processes . . .
- Quality Control perfections, such as automatic gauging.

New manufacturing facilities

The six plants of the General Electric Company Plastics Divisions, which are strategically located to serve American industry, are now better tooled than ever before. There are 1,400 presses for compression, injection, transfer and cold molding. There are improved facilities for high- and low-pressure laminating. Two more General Electric plastics plants are now being built.

New "know-how"

The engineers, chemists, designers, and production men who put plastics in the war at General Electric make up one of the largest technical staffs in the plastics industry, and theirs is a great wartime accumulation of plastics "know-how."

New plastics concept

Visit the mold vault at No. 1 Plastics Avenue. More than 8,000 molds are stored there for possible future use. You see one mold that has been in production ever since 1904. You see molds

for the production of military equipment—these may well prove to be an enduring record of what plastics did to help win the war. And you realize that there is something new in American industrial technique.

It might be compared to printing from movable type—the invention that did more than any other to bring about modern civilization. Yes, plastics manufacturing is publishing . . . publishing in three dimensions. And General Electric is now the largest manufacturer of finished plastics parts in the world.

AN UNBIASED SOURCE OF PLASTICS INFORMATION

General Electric recommends the use of plastics when they fill one of three conditions—

1. *When plastics will do the same job as another material for less money.*
2. *When plastics will do a better job for the same money.*
3. *When plastics will do a job no other material can do.*

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